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AMERICAN MACHINE & FOUNDRY COMPANY

GREENWICH ENGINEERING DIVISION

GREENWICH, CONN.

VOLUME II

# HUMAN FACTORS ENGINEERING REVIEW AND EVALUATION

## WEAPON SYSTEM 107A-2 LAUNCHER, OSTF AND TF-1

## FINAL REPORT

CONTRACT NUMBER AF 04(647)-130

HUMAN FACTORS ENGINEERING

TECHNICAL STAFF


AMERICAN MACHINE & FOUNDRY COMPANY

GREENWICH ENGINEERING DIVISION

GREENWICH, CONN.

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In 3 Volumes

# HUMAN FACTORS ENGINEERING REVIEW AND EVALUATION OF TITAN WEAPON SYSTEM 107A-2 LAUNCHER, OSTF & TF-1

## FINAL REPORT

Contract No. AF 04(647)-138


The Human Factors Engineering Group
Technical Staff


31 January 1962
Volume II
Chapter 16 - 26


AMERICAN MACHINE & FOUNDRY COMPANY
GREENWICH ENGINEERING DIVISION
GREENWICH, CONNECTICUT

# Chapter 16

## Human Factors Review and Evaluation of the Tug Truck

KEY SWITCH

A key switch prevents unauthorized use of vehicle.

HORN

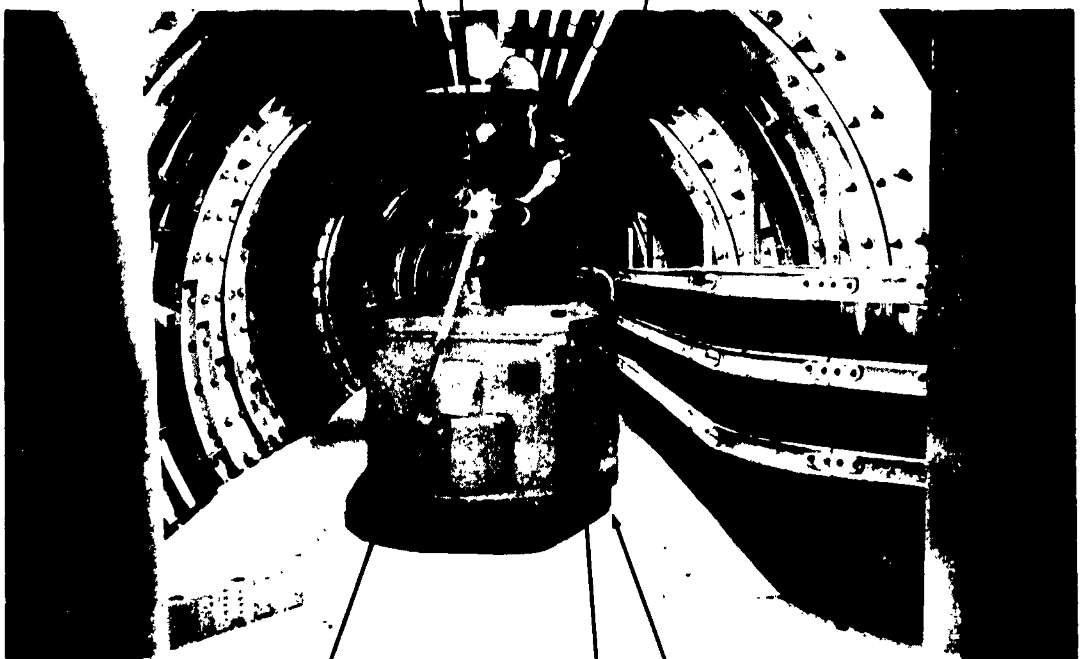
A horn has been provided to warn personnel of impending hazards.

FIRE EXTINGUISHER

A fire extinguisher should be affixed where it can be easily reached.

SEAT

Provide for safe and efficient seated operation to allow head clearance in low tunnel passages and to reduce accident possibilities.



FAIL SAFE CONTROL

Dead man controls have been provided to improve safety.

HOISTING EQUIPMENT

Handling assistance for removal of heavy batteries should be provided.

STEERING GUIDANCE

Provide a steering guidance system to facilitate tunnel turning & backing.

CONDUCTIVE TIRES

Vehicle is equipped with conductive tires to reduce sparking

ACCESS OPENINGS

Access for maintenance has been provided.

FIGURE 16-1
HUMAN FACTORS INPUTS
TUG TRUCK

**SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO:**
TUG TRUCK

| No. | Factor | Human Factor Effort Required | PHASE II STAGE | | | | HUMAN FACTORS OBJECTIVE | | | | | APPLICABLE ON MODEL | | | SYMBOL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Concept | Review | Analysis | Field Input | Specification Compliance | Safety | Operational Status | Maintenance Recommendation | Product Improvement | OSTF | TF | OB | |
| | **1.0 HUMAN ENGINEERING DESIGN FACTORS** | | | | | | | | | | | | | | |
| 1.1 | Anthropometric Compatability | * | * | | * | * | * | * | | | * | * | * | * | |
| 1.2 | Controls and Displays | | | | | | | | | | | | | | |
| 1.3 | Fail-Safe Design | * | * | | | | * | * | | | | * | * | * | |
| 1.4 | Malfunction Detection | | | | | | | | | | | | | | |
| | **2.0 MAINTENANCE FACTORS** | | | | | | | | | | | | | | |
| 2.1 | Access, Visual | | | | | | | | | | | | | | |
| 2.2 | Access, Servicing | * | | * | | | * | | | | | * | * | * | |
| 2.3 | Remove and Replace | | | | | | | | | | | | | | |
| 2.4 | Handling, Physical Limitations | * | | * | | | * | | | | | * | * | * | |
| 2.5 | Handling, Transportation | | | | | | | | | | | | | | |
| 2.6 | Vehicle Maneuverability | * | | | * | * | * | | | | * | * | * | * | |
| | **3.0 SAFETY FACTORS** | | | | | | | | | | | | | | |
| 3.1 | Chemical Decontamination | | | | | | | | | | | | | | |
| 3.2 | Escape Provisions | | | | | | | | | | | | | | |
| 3.3 | Protection from Entanglement | | | | | | | | | | | | | | |
| 3.4 | Protection from Falling | | | | | | | | | | | | | | |
| 3.5 | Safety Devices (other) | * | * | | | | * | * | | | | * | * | * | |
| 3.6 | Warning Devices | * | * | | | | * | * | | | | * | * | * | |
| | **4.0 PHYSIOLOGICAL FACTORS** | | | | | | | | | | | | | | |
| 4.1 | Biological Damage | | | | | | | | | | | | | | |
| 4.2 | Vertigo | | | | | | | | | | | | | | |
| 4.3 | Vibration Effects | | | | | | | | | | | | | | |
| | **5.0 PSYCHOLOGICAL FACTORS** | | | | | | | | | | | | | | |
| 5.1 | Fear of Heights | | | | | | | | | | | | | | |
| 5.2 | Fear of Being Crushed | | | | | | | | | | | | | | |
| 5.3 | Fear of Falling | | | | | | | | | | | | | | |
| 5.4 | Fear of Isolation | | | | | | | | | | | | | | |
| 5.5 | Feeling of Insecurity | | | | | | | | | | | | | | |
| | **6.0 ENVIRONMENTAL FACTORS** | | | | | | | | | | | | | | |
| 6.1 | Acoustic Energy (noise) | | | | | | | | | | | | | | |
| 6.2 | Humidity & Temperature | | | | | | | | | | | | | | |
| 6.3 | Illumination | | | | | | | | | | | | | | |
| | **7.0 HUMAN USE FACTORS** | | | | | | | | | | | | | | |
| 7.1 | Procedure | | | | | | | | | | | | | | |
| 7.2 | Time Study | | | | | | | | | | | | | | |
| 7.3 | Training/Selection | | | | | | | | | | | | | | |

FIGURE 16-2

## 1.0 DESCRIPTION

1.1 The Tug Truck is a vehicle used for towing the maintenance dolly, the mobile work platform, the flat bed trailers, etc., between the Ready Maintenance Room in the Command Control Center and the missile silo areas via the personnel access tunnels. The Tug Truck is battery powered and controlled through electrical interlocks which provide a dead man safety feature. Power is automatically cut off and the brake is applied when the control handle is released from either operating position. The Tug is capable of pulling a 4,000 lb. load at a speed of 2 to 4 miles per hour while ascending a 5% grade and the battery life is rated at 432 ampere hours.

1.2 Men of the Air Force population who represent body sizes between the 5th and 95th percentile must be able to operate the Tug Truck efficiently within the tunnels without causing damage to equipment or injury to personnel. The vehicle must be designed to provide adequate access to batteries and other parts requiring frequent service, and where maintenance tasks require removal of components heavier than a man can safely lift, special handling devices must be provided. All of these factors contributing to the successful use of the Tug Truck have been itemized on the Summary Checklist (Figure 16-2) and the progress of the Tug Truck design has been tabulated in detail in the following Synopsis.

ITEM: TUG TRUCK

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE | | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA | | VERIFICATION | | | RESULTS | % |
|---|---|---|---|---|---|---|---|---|---|---|
| | CONTRACTUAL AFBM 57-1A | TECH REF. | | PARTICIPATION | RECOMMENDATIONS | ANAL | EQUIP | TEST | | |
| 1.0 HUMAN ENGINEERING DESIGN<br>1.1 ANTHROPOMETRIC COMPATABILITY | PAR. 6.1.1 | ASA 253.1<br>PAR. 2.3<br><br>ARB-1005C<br>PAR. 4.14 | MINIMUM OVERHEAD HEIGHT IN STANDING POSITION IS 73". TUG TRUCK PLATFORM IS 8" HIGH. HARD HAT ADDS 1" TO HEIGHT AND SHOE HEEL ADDS 1" TO HEIGHT. THEREFORE THE MINIMUM ACCEPTABLE OVERHEAD CLEARANCE IN THE TUNNEL SHOULD BE 83". THIS MEASUREMENT TO BE MADE FROM THE TUG TRUCK ROADWAY TO THE LOWEST HANGING INSTALLATION AND AT THE SMALLEST TUNNEL APERTURE ALONG THE ROUTE. | HB-STB-#190 3/16/59. | THE MINIMUM TUNNEL APERTURE IS AT THE BLAST DOOR FRAME WHERE THE OVERHEAD HEIGHT IS ONLY 78". IT WAS RECOMMENDED THAT ANY INSTALLATION, FIXTURE, OR OVERHEAD AREA BELOW 83" BE PAINTED IN ALTERNATE 2" BANDS OF YELLOW AND BLACK STRIPS INCLINED 45° PER ASA Z53.1-1953 (REF. 3). THE PROBLEM IS EVEN MORE SERIOUS AT OR BECAUSE OF REDUCED TUNNEL DIAMETER WHICH FURTHER LIMITS OVERHEAD CLEARANCE. A TUG TRUCK WHICH WOULD ALLOW THE DRIVER TO SIT DOWN WAS RECOMMENDED. | X | X. | X | THE TF TUNNELS HAVE BEEN PAINTED PER RECOMMENDATION. PROPOSED CHANGES INCLUDE A MODIFICATION TO LOWER THE OPERATING POSITION OF THE HANDLE, ALSO INCLUDED IS A SEAT TO PROVIDE OPERATION FROM A FULLY SEATED POSITION. | 30 |
| 1.3 FAIL SAFE DESIGN | PAR. 1.4 | ASA 256-1<br>PAR. 613 | THE TUG TRUCK DESIGN SHOULD BE SUCH THAT UNDER NO CONDITIONS CAN THE VEHICLE ROLL WITHOUT AN OPERATOR AT THE CONTROLS. THE TUG TRUCK CONTROLS SHOULD HAVE A "DEAD MAN CONTROL" FOR THIS PURPOSE. | | THE TUG TRUCK STEERING ARM HANDLE HAS A "DEAD MAN CONTROL" FEATURE. THIS MEANS THAT WHENEVER THE OPERATOR DOES NOT MAINTAIN PRESSURE ON THE STEERING ARM HANDLE, POWER IS CUT OFF AND THE BRAKES ARE APPLIED. | | X | | ADOPTED | 30 |

2.0 SYNOPSIS

ITEM: TUG TRUCK

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: CONTRACTUAL AFBM 57-8A | DOCUMENTARY COMPLIANCE: TECH REF. | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION: ANAL | VERIFICATION: DEMO | VERIFICATION: TEST | RESULTS | RELATIVE VALUE % |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.0 MAINTENANCE FACTORS<br>2.2 ACCESS SERVICING | PAR. 4.3.3.9.3.1 | | REMOVAL OF ANY REPLACEABLE UNIT SHALL REQUIRE OPENING OR REMOVAL OF A MINIMUM NUMBER OF COVERS, OR PANELS (PREFERABLY ONE). | | THE TUG TRUCK BATTERIES ARE ACCESSIBLE WHEN THE BATTERY CASE COVER WHICH IS FASTENED BY FOUR SCREWS IS REMOVED. AN ELECTRICAL OUTLET HAS BEEN PROVIDED TO FACILITATE THE ATTACHMENT OF THE BATTERY CHARGER LEADS AND TO ELIMINATE THE NEED FOR REMOVING THE BATTERY COVER FOR THIS PURPOSE. | | X | | ACCESSIBILITY IS ADEQUATE | 5 |
| 2.4 HANDLING, REMOVE - REPLACE | PAR. 4.3.3.1 | ABS 1003C PAR. 4.15<br>ABA 886-1 PAR. 7058 | SPECIAL HANDLING EQUIPMENT MUST BE PROVIDED FOR UNITS EXCEEDING 142 LBS. WHICH MUST BE LIFTED MORE THAN ONE FOOT. THE BATTERY MUST BE LIFTED APPROX. 3 FEET AND WEIGHS 145 LBS. | | IT IS RECOMMENDED THAT SOME HANDLING DEVICE, A SLING OR AN ADAPTER BE PROVIDED FOR LIFTING THE BATTERY WHICH WOULD BE COMPATIBLE FOR USE WITH THE MAINTENANCE DOLLY OR OTHER LIFTING DEVICE. | | X | | NOT ADOPTED | 5 |
| 2.6 VEHICLE MANEUVERABILITY | | ABS 1003D PAR. 3.3.1 3.1.5.1 | THE TUG TRUCK MUST PERFORM ITS FUNCTIONS WITHIN A MINIMUM TIME INTERVAL AND WITH A MINIMUM AMOUNT OF OPERATOR DISCOMFORT. | ER-STB-190 3/16/59. | HUMAN FACTORS REVIEW OF THE TUNNEL CLEARANCE REQUIREMENTS (FOR THE TUG TRUCK) REVEALED THAT THE TUG TRUCK OPERATIONS WERE EXTREMELY TIME CONSUMING AND THAT DIFFICULTIES ENCOUNTERED BY THE OPERATOR WERE EXCESSIVE. (SEE 1.1 OF THIS CHART). THE FOLLOWING RECOMMENDATIONS WERE MADE: | X | X | X | STL/BMD DID NOT AGREE WITH [illegible] | 20 |

2.0 SYNOPSIS

ITEM: TOW TRUCK

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: CONTRACTUAL APPENDIX A | DOCUMENTARY COMPLIANCE: TECH REF. | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION: ANAL | VERIFICATION: DEMO | VERIFICATION: TEST | RESULTS | DATA ANALYSIS |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.6 VEHICLE MANEUVERABILITY (CONT'D) | | | | | 1. A STEERING GUIDANCE PLAN SHOULD BE ADOPTED WHICH WILL BE COMPATIBLE WITH THE CLOSE TOLERANCES OF THE TUNNELS AND VEHICLES SO THAT HUMAN ERROR IS ELIMINATED AND TRANSIT TIME KEPT TO A MINIMUM. 2. TRAFFIC WARNING SIGNALS SHOULD BE USED TO KEEP THE MOVEMENT OF VEHICLES AND PERSONNEL IN THE TUNNELS SAFE AND ORDERLY. 3. A COMPLETE STUDY SHOULD BE MADE OF TUNNEL TRANSPORTATION PROBLEMS EMPHASIZING VEHICLE STEERING GUIDANCE AND GENERAL SAFETY USING AS MUCH EXISTING FACILITY AND CONTRACTOR EQUIPMENT AS POSSIBLE. | | | | | |
| 3.0 SAFETY<br>3.5 SAFETY DEVICES (OTHER) | PAR. 7.2 | ABS - 1003C PAR. 3.2.1 | TO PREVENT UNAUTHORIZED OPERATION OF THE TOW TRUCK, A KEY LOCKED IGNITION SWITCH SHOULD BE INCORPORATED. | | THE TOW TRUCK CONTROLS INCLUDE A KEY LOCKED IGNITION SWITCH. | | X | | CRITERIA SATISFIED | 5 |
| | PAR. 7.11 | ABS - 1003C PAR. 6.4.1 | TO MINIMIZE DAMAGE CAUSED BY A FIRE RESULTING FROM A COLLISION, A FIRE EXTINGUISHER SHOULD BE AFFIXED TO THE TOW TRUCK. | | A FIRE EXTINGUISHER IS PROVIDED ON THE TOW TRUCK. | | X | | CRITERIA SATISFIED | 5 |

ITEM: TUG TRUCK

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE | | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA | | VERIFICATION | | | RESULTS | % ATTAIN VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| | CONTRACTUAL AFSCM 57-8A | TECH. REF. | | PARTICIPATION | RECOMMENDATIONS | ANAL | EQUIP | TEST | | |
| 3.5 SAFETY DEVICES (OTHER) (CONT'D) | | AMS - 1008 D PAR. 3.1.10.1<br>AMS - 1003C PAR. 4.4.1 G | THE TUG TRUCK OPERATES IN OR NEAR HAZARDOUS AREAS WHERE SPARKING IS NOT TOLERABLE. TO REDUCE THE POSSIBILITY OF BUILDUP OF STATIC CHARGE, THE TUG TRUCK SHOULD HAVE CONDUCTIVE WHEELS. | | THE TUG TRUCK IS EQUIPPED WITH CONDUCTING TIRES ON ITS WHEELS. | | X | | CRITERIA SATISFIED | 5 |
| 3.6 WARNING DEVICES | PAR. 7.3 | AMS - 1003C PAR. 4.4 | A HAZARD ALERTING DEVICE SHOULD BE PROVIDED TO WARN PERSONNEL OF IMPENDING OR EXISTING HAZARDS. | | THE TUG TRUCK IS EQUIPPED WITH A HORN OPERATED BY THE DRIVER. | | X | | CRITERIA SATISFIED | 5 |

2.0 SYNOPSIS

## 3.0 DISCUSSION

The tunnel cross-section and the anthropometric dimensions of operating personnel cannot be compromised. A Tug Truck which allows the driver to sit down (HF-T-1041) would reduce the necessary overhead clearance from 83" to 71.6". Additional benefits resulting from the paramount objective of sufficient head clearance would be greater driver comfort (seated operation) increased maneuvering efficiency (no ducking, bending distractions) and increased speed (no fear of physical injury).

An integrated traffic study (all contractors' traffic problems) should be conducted to determine the optimum method of transportation with the minimum time consumption to complete the tasks. The existing wooden guide rails limit operator efficiency and restrict the number of units in tow to one. Backing and turning within tunnel junctions using the present system is a time consuming operation involving several workers. Guidance systems have been proposed which would be compatible with present vehicles and would increase the efficiency of vehicular transportation in the tunnels.

## 4.0 REFERENCES


1. AFBM Exhibit 57-8A, Human Engineering Design Standards for Missile System Equipment.
2. ASA Z53.1-1953, Safety Color Code for Marking Physical Hazards and Identification of Certain Equipment.
3. AMS 1001D-Detail Model Spec. for WS 107A-2 Launcher System.
4. AMF Design Specification - ADS 1003C - Personnel Safety for WS 107A-2 Launcher System.
5. ASA B56-1 - Safety Code for Industrial Power Trucks.
6. AHFP-V-5226 - Human Factors Test Procedure for Evaluation of the Tug Truck - WS 107A-2 Launcher System.
7. AMF Report, ER-TPS-190, Tunnel Guidance Requirements OSTF-TB-OB, 3/16/59.
8. AMF Report, ER-V-92, Operational Test of the Tug Truck with Mobile Maintenance GSE, 3/13/61.
9. AMF Report, ER-TPS-121, Tug Truck Requirements, 10/6/58.
10. AMF Report, ER-TPS-119, Human Engineering Study of Clearance in Tunnel for Personnel, 9/30/58.
11. AMF Report, FTR-V-408, Tug Truck Design Changes, 10/17/61.
12. AMF Drawing No. HF-T-1041 - Tug Truck, Seated Operator versus OB Tunnels.

13. AMF Drawing No. HF-T-1158 - Study, Rail Guidance System OB Tunnel.

# Chapter 17

## Human Factors Review and Evaluation of the Power Pack

NOISE PROTECTION

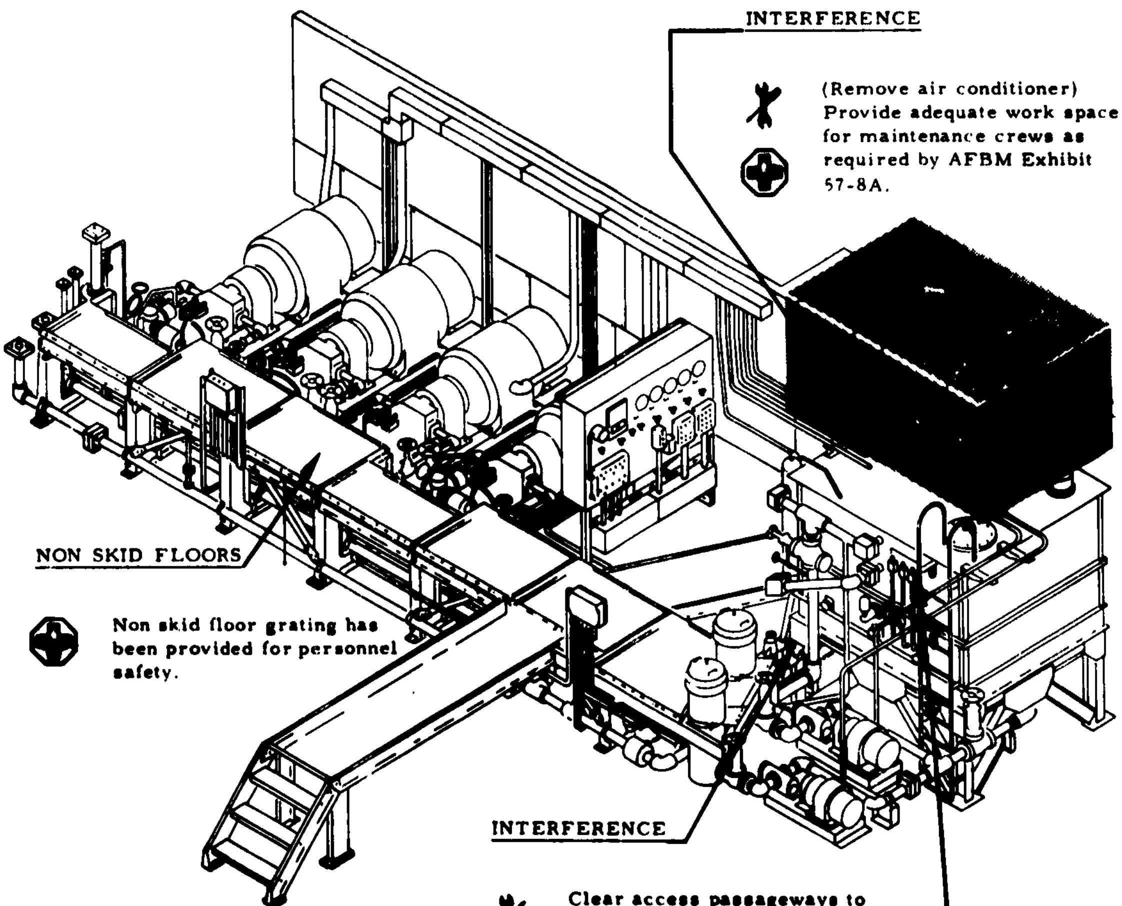
Provide noise protection to reduce human error in telephone conversations, to reduce possibilities of injury to personnel, and to increase efficiency of human performance.

LABELS

Permanent labels should be provided for each control and display.

INTERFERENCE

(Remove air conditioner) Provide adequate work space for maintenance crews as required by AFBM Exhibit 57-8A.



NON SKID FLOORS

Non skid floor grating has been provided for personnel safety.

INTERFERENCE

Clear access passageways to all essential instruments and for normal maintenance operations.

WARNING SIGNS

Provide hazard warning signs to comply with A.S.A. Z 35.1 - R 1945.

LADDER

Provide ladders to comply with A.S.A. A 14.3 - 1956

FIGURE 17-1
HUMAN FACTORS INPUTS
POWER PACK
ROOM

CONTROL - DISPLAY ARRANGEMENTS

Arrange controls and displays to comply with AFBM Exhibit 57-8A.

WARNING HORN

A warning horn indicates trouble in essential functions of the hydraulic supply system.

INDICATORS

Controls and displays associated with warning devices should be connected to circuitry which is fail safe (self checking against human error).

PRESSURE GAUGES

Locate pressure gauges so that normal readings are at 9 o'clock position.

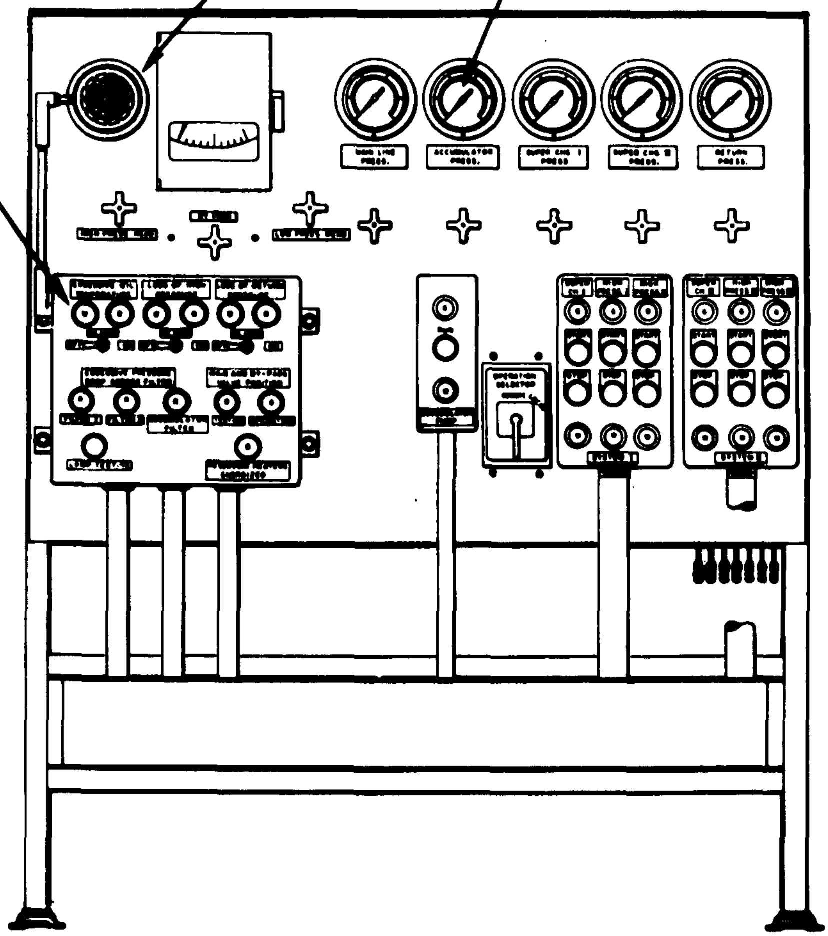


FIGURE 17-2
HUMAN FACTORS INPUTS
CYCLING CONTROL
STATION

**SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO:**
POWER PACK

| | | | PHASE IN STAGE | | | | | HUMAN FACTORS OBJECTIVE | | | | APPLICABLE ON MODEL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Human Factor Effort Required | Concept | Review | Analysis | Field Input | Specification Compliance | Safety | Operational Status | Maintenance Recommendation | Product Improvement | OSTF | TP | OB | SYMBOL |
| | **1.0 HUMAN ENGINEERING DESIGN FACTORS** | | | | | | | | | | | | | | |
| 1.1 | Anthropometric Compatability | * | | * | | | | | | * | | * | * | * |  |
| 1.2 | Controls and Displays | * | | * | | | | | * | | | * | * | * | |
| 1.3 | Fail-Safe Design | | | | | | | | | | | | | | |
| 1.4 | Malfunction Detection | | | | | | | | | | | | | | |
| | **2.0 MAINTENANCE FACTORS** | | | | | | | | | | | | | | |
| 2.1 | Access, Visual | | | | | | | | | | | | | |  |
| 2.2 | Access, Servicing | * | | * | | | | | | * | | * | * | * | |
| 2.3 | Remove and Replace | * | | * | | | | | | * | | * | * | * | |
| 2.4 | Handling, Physical Limitations | | | | | | | | | | | | | | |
| 2.5 | Handling, Transportation | | | | | | | | | | | | | | |
| 2.6 | Vehicle Maneuverability | | | | | | | | | | | | | | |
| | **3.0 SAFETY FACTORS** | | | | | | | | | | | | | | |
| 3.1 | Chemical Decontamination | | | | | | | | | | | | | |  |
| 3.2 | Escape Provisions | | | | | | | | | | | | | | |
| 3.3 | Protection from Entanglement | | | | | | | | | | | | | | |
| 3.4 | Protection from Falling | * | | * | | | | * | | | | * | * | * | |
| 3.5 | Safety Devices (other) | | | | | | | | | | | | | | |
| 3.6 | Warning Devices | * | | * | | | | * | | | | * | * | * | |
| | **4.0 PHYSIOLOGICAL FACTORS** | | | | | | | | | | | | | | |
| 4.1 | Biological Damage | | | | | | | * | | | | | | |  |
| 4.2 | Vertigo | | | | | | | | | | | | | | |
| 4.3 | Vibration Effects | | | | | | | | | | | | | | |
| | **5.0 PSYCHOLOGICAL FACTORS** | | | | | | | | | | | | | | |
| 5.1 | Fear of Heights | | | | | | | | | | | | | |  |
| 5.2 | Fear of Being Crushed | | | | | | | | | | | | | | |
| 5.3 | Fear of Falling | | | | | | | | | | | | | | |
| 5.4 | Fear of Isolation | | | | | | | | | | | | | | |
| 5.5 | Feeling of Insecurity | | | | | | | | | | | | | | |
| | **6.0 ENVIRONMENTAL FACTORS** | | | | | | | | | | | | | | |
| 6.1 | Acoustic Energy (noise) | * | | * | | | | | | * | | * | * | * |  |
| 6.2 | Humidity & Temperature | | | | | | | | | | | | | | |
| 6.3 | Illumination | | | | | | | | | | | | | | |
| | **7.0 HUMAN USE FACTORS** | | | | | | | | | | | | | | |
| 7.1 | Procedure | | | | | | | | | | | | | |  |
| 7.2 | Time Study | | | | | | | | | | | | | | |
| 7.3 | Training/Selection | | | | | | | | | | | | | | |

FIGURE 17-3

## 1.0 DESCRIPTION OF THE POWER PACK ROOM

1.1 The power pack supplies the hydraulic power used to move the launcher platform, silo doors, work platforms, and other components in the Titan Launcher System. The equipment in the Power Pack Room includes the following:

a. A reservoir of sufficient capacity to supply fluid to all of the hydraulic cylinders and motors throughout the system which must be actuated at a given time.

b. Pumping systems which are connected to the reservoir by a common feed line through a manual shut off valve.

c. Two accumulators ("Greer" Model 30A-10A 3/4) which store hydraulic energy supplied on demand by a fixed displacement pump. An Accumulator Circuit Mounting Panel connects the accumulators to the pump which automatically maintains a standby pressure of 500 psi throughout the system.

d. A Cycling Control Station used as a local control during cycling tests.

e. Grating and pipe supports which are used as catwalks and a means of holding the pipe lines.

f. Two Pressure Switch Boxes which electrically connect pressure points within the Power Pack to the Annunciator Panel indicators.

## 1.2 APPLICABLE HUMAN FACTORS CONSIDERATIONS FOR THE POWER PACK ROOM

Equipment in the Power Pack Room must be designed for operation by Air Force personnel between the 5th and 95th percentile. Controls and displays should be designed and located so as to reduce the probability of operator error. Warning labels and alerting devices

should be provided for potentially hazardous conditions. Access should be provided for all equipment which requires maintenance. Steps should be taken to reduce the noise level if it interferes with operator performance or is physically detrimental to personnel. Factors contributing to the successful use of the Power Pack have been itemized on the summary checklist (Fig. 17-3) and the progress of the Power Pack design has been tabulated in detail in the following synopsis.

ITEM: POWER PACK ROOM

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: CONTRACTUAL AFBM 57-8A | DOCUMENTARY COMPLIANCE: TECH REF. | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION: ANAL | VERIFICATION: EQUIP | VERIFICATION: TEST | RESULTS | % RELATIVE VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 HUMAN ENGINEERING DESIGN FACTORS<br>1.2 CONTROLS AND DISPLAYS | PAR. 2.2.1 | | LABELS SHOULD BE LOCATED ADJACENT TO CONTROLS AND DISPLAYS TO BE IDENTIFIED AND SHOULD IDENTIFY ACCORDING TO FUNCTION. | DRAWING REVIEW AND ENGINEERING REPORT ER-TPS-206 | LABELS SHOULD BE PROVIDED FOR MANUAL SHUTOFF VALVES ON THE ACCUMULATOR CIRCUIT PANEL AND FOR CONTROLS AND DISPLAYS ON THE CYCLING CONTROL STATION. | | X | | NOT ADOPTED | 5 |
| | PAR. 2.2.2.4 | | LABELS SHOULD BE ETCHED OR EMBOSSED. | SAME AS ABOVE | LABELS FOR ALL PANELS IN THE POWER PACK ROOM SHOULD BE ETCHED OR EMBOSSED. | X | X | | NOT ADOPTED | 5 |
| | PAR. 2.3.1.3.2 | | WARNING LIGHTS SHOULD BE USED TO INDICATE THE CONDITION OF A SUBSYSTEM IN ADDITION TO LIGHTS WHICH SHOW THE STATUS OF SUB-SYSTEM COMPONENTS. | SAME AS ABOVE | ONE RED LIGHT INDICATOR ON THE ANNUNCIATOR PANEL WAS RECOMMENDED FOR EACH OF THE FOLLOWING TROUBLE CIRCUITS: EXCESSIVE OIL TEMPERATURE; LOSS OF HIGH PRESSURE; LOSS OF RETURN PRESSURE; LOW OIL SUPPLY; EXCESSIVE PRESSURE DROP ACROSS FILTER I, FILTER II, ACCUMULATOR FILTER. | X | X | | NOT ADOPTED | 5 |
| | PAR. 2.1.4 AND 3.1.4 | | PROCEDURES ARE DESCRIBED FOR THE LOCATION OF DISPLAYS AND CONTROLS TO REDUCE OPERATING TIME AND THE PROBABILITY OF OPERATOR ERROR. | SAME AS ABOVE. | RECOMMENDATIONS WERE MADE FOR THE ARRANGEMENT OF CONTROLS AND DISPLAYS ON THE CYCLING CONTROL STATION AND THE ANNUNCIATOR CONTROL PANEL ASSEMBLY. | X | X | | NOT ADOPTED | 5 |

2.0 SYNOPSIS

ITEM: POWER PACK ROOM

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE | | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA | | VERIFICATION | | | RESULTS | RELATIVE VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| | CONTRACTUAL AFBM 57-8A | TECH REF. | | PARTICIPATION | RECOMMENDATIONS | ANAL | EQUIP | TEST | | |
| 1.2 CONTROLS AND DISPLAYS (CONTINUED) | | "HUMAN ENGINEERING" BY E. V. MC CORMICK, PG. 375 | THE READING OF GAUGES CAN BE SIMPLIFIED BY ARRANGING THE GAUGES SO THAT THE NORMAL POINTER CONDITION IS INDICATED BY A STANDARD LOCATION ON ALL INSTRUMENTS. | SAME AS ABOVE | THE PRESSURE GAUGES ON THE CYCLING CONTROL STATION SHOULD BE ORIENTATED SO THAT THEIR NORMAL READING IS AT THE 9 O'CLOCK POSITION. | X | X | | NOT ADOPTED | 5 |
| | APPENDIX I | LETTERS FROM AFBMD TO AMF 2/11/59 AND 12/2/59 | THE EXTERIOR COLORS TO BE USED FOR THE EQUIPMENT ARE DETAILED. | SAME AS ABOVE | HUMAN FACTORS RECOMMENDED THAT THE PANELS IN THE POWER PACK ROOM BE PAINTED TO CONFORM WITH COLORS REQUIRED IN REFERENCED LETTER. | | | | ADOPTED | 5 |
| 2.0 MAINTENANCE FACTORS<br>2.2 ACCESS, SERVICING | PAR. 4.3.3.9.1.4 | | PIPES SHOULD NOT INTERFERE WITH ACCESS TO EQUIPMENT. | SAME AS ABOVE | IN THE POWER PACK ROOM PIPING BETWEEN THE HEAT EXCHANGER ON THE RESERVOIR AND THE PIPING SUPPORTS UNDER THE GRATING SHOULD BE RE-ROUTED. THIS WOULD PERMIT ACCESS TO RESERVOIR GAUGES AND LADDERS WITHOUT REQUIRING THE OPERATOR TO STEP OVER THE PIPES. | X | X | | NOT ADOPTED | 5 |
| | PAR. 4.3.3.9.1.8 | | BULKHEADS, BRACKETS, AND OTHER UNITS SHOULD NOT INTERFERE WITH ACCESS TO UNITS WHERE WORK MUST BE DONE. | DRAWING REVIEW AND ENGINEERING REPORT ED-TPS-342. | THE AIR CONDITIONING UNIT OCCUPIES THE SPACE ABOVE THE HYDRAULIC RESERVOIR. THE UNIT SHOULD BE MOVED TO PERMIT ACCESS TO THE RESERVOIR FOR THE PURPOSE OF MAINTAINING THE PROPER FLUID LEVEL AND CHANGING THE SUCTION STRAINER. | X | X | | NOT ADOPTED | 15 |

2.0 SYNOPSIS

ITEM: [illegible]

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: CONTRACTUAL AFBM 57-9A | DOCUMENTARY COMPLIANCE: TECH. REF. | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION: ANAL | VERIFICATION: EQUIP | VERIFICATION: TEST | RESULTS | RELATIVE VALUE % |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.2 ACCESS, SERVICING (CONTINUED) | | A.S.A. A14.3-1956 | REQUIREMENTS FOR FIXED LADDERS ARE SPECIFIED. | DRAWING REVIEW AND ENGINEERING REPORT ER-GTS-306. | THE FOLLOWING RECOMMENDATIONS WERE MADE: A. MINIMUM CLEARANCE BETWEEN SIDE RAILS SHOULD BE 16 INCH. B. MINIMUM ROD DIAMETER FOR LADDER RUNGS SHOULD BE .75 INCHES C. MINIMUM DISTANCE BETWEEN TOP HAND-RAIL EXTENSIONS SHOULD BE 21.A INCHES | X | X | | NOT ADOPTED | 12 |
| 3.0 SAFETY FACTORS 3.4 PROTECTION FROM FALLING | PAR. 7.32 | | SKID PROOF FLOORING SHOULD BE PROVIDED ON STAIR AND STEP TREADS. | SAME AS ABOVE | NON-SKID WALKING SURFACES SHOULD BE PROVIDED ON ALL CAT WALKS. | X | X | | ADOPTED | 10 |
| 3.6 WARNING DEVICES | PAR. 7.1 AND 7.30 | ASA Z 35.1 R-1959 | PLACARDS SHOULD BE PLACED TO WARN OF POTENTIALLY HAZARDOUS CONDITIONS. | SAME AS ABOVE | A CAUTION SIGN SHOULD BE PLACED 65 INCHES FROM THE FLOOR ON THE CENTER LINE OF THE LADDER MOUNTED ON THE RESERVOIR TANK. THE SIGN SHOULD READ: "CAUTION HEAD CLEARANCE ON TOP A FEET 8.5 INCHES" A LABEL SHOULD APPEAR ON EACH ACCUMULATOR TO WARN THE OPERATOR TO (1) RELEASE FLUID PRESSURE BEFORE DISCONNECTING THE PRESSURE LINE AND (2) RELEASE GAS AND FLUID PRESSURE BEFORE DISASSEMBLING THE ACCUMULATOR. | X | X | | NOT ADOPTED | 5 |

ITEM: POWER PACK ROOM

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: CONTRACTUAL AFBM 57-8A | DOCUMENTARY COMPLIANCE: TECH REF. | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION: ANAL | VERIFICATION: EQUIP | VERIFICATION: TEST | RESULTS | % RELATIVE VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| 3.6 WARNING DEVICES (CONTINUED) | PAR. 7.3 | | A HAZARD ALERTING DEVICE SHOULD BE PROVIDED TO WARN PERSONNEL OF IMPENDING OR EXISTING HAZARDS. | DRAWING REVIEW AND ENGINEERING REPORT ER-TPS-306. | AN AUDIBLE HORN CIRCUIT SHOULD BE PROVIDED WHICH WOULD BE ENERGIZED TO INDICATE TROUBLE IN THE FOLLOWING CIRCUITS:<br>A. EXCESSIVE OIL TEMPERATURE,<br>B. LOSS OF HIGH PRESSURE,<br>C. LOSS OF RETURN PRESSURE, AND<br>D. LOW OIL SUPPLY. | X | X | | ADOPTED | 10 |
| 4.0 ENVIRONMENTAL FACTORS<br>4.1 ACOUSTIC ENERGY (NOISE) | PAR. 5.1.4.2 AND 5.1.4.4 | | NOISE IS REDUCED BY CONSTRUCTING BARRIERS BETWEEN THE WORK AREA AND THE SOURCE OF NOISE AND BY ENCLOSING REMOTE CONTROL STATIONS. | SAME AS ABOVE ALSO FIELD TESTS UNOFFICIAL NOISE READINGS, COMMENTS ON ADTP-W-6085 (POWER PACK TEST PLAN) AND OBSERVATIONS MADE BY HUMAN FACTORS ENGINEERS WHILE VISITING THE FIELD (TF-1) ALL INDICATE THAT NOISE LEVELS WITHIN THE POWER PACK ROOM PROBABLY VIOLATE AFBM-57-8A AND NOISE SPECIFICATIONS REFERENCED THEREIN. OFFICIAL TEST DATA WHICH IS THE INTENT OF ADTP-W-6325 (HYDRAULIC SUPPLY ROOM NOISE-LEVEL TESTS) HAS NOT YET BEEN COMPLETED. | THE CYCLING CONTROL STATION INCLUDING THE TELEPHONE SHOULD BE HOUSED WITHIN A SOUND BARRIER TO DECREASE THE EFFECTS OF NOISE. | X | X | X | NOT ADOPTED | 15 |

3.0 DISCUSSION FUTURE DEVELOPMENT PROGRAMS

3.1 Problem areas which should be considered early in the concept stage of future hydraulic power pack designs are:

a. Access to all manual valves should be provided for visual inspection, adjustment, and servicing. Visual access must also be provided to all gauges, thermometers, flow meters, etc. so they can be read easily and accurately.

b. Personnel must not be exposed to noise levels which can permanently cause hearing loss or can temporarily reduce effective use of voice communication, telephone conversation or warning devices.

3.2 The following concept is recommended to improve future power packs with respect to human factors:

a. Divide the power pack room into two sections separated by a sound proof wall.

b. Locate all pumps, filters, valves, piping and the reservoir along the back side of the wall so that valve handles, gauges, level indicators, thermometers, etc. appear on the front side in proper juxtaposition along a line schematic of the system.

c. Color code the painted lines to represent various required pressures.

d. Provide a vibration insulated catwalk along the entire length of the control surface with one large insulated door for access to the machinery side.

Operators will be able to instruct new personnel using the flow diagram as a training aid and the system will be easy to trace for malfunctions. Noise will not interfere with conversations

and warning devices. Personnel will not be subjected to injurious noise levels which can temporarily decrease efficiency and permanently impair hearing.

## 4.0 REFERENCES


1. AFBM Exhibit 57-8A, Human Engineering Design Standards for Missile System Equipment.

2. AFBMD, Deviation from WDT Policy Memorandum #7 Color Schemes for Console Panels, etc., 2/11/59.

3. AFBMD, Colors for Ground Equipment, 12/2/59.

4. ASA, A14.3-1956, Fixed Ladders.

5. ASA, Z35.1 - R 1945, Specifications for Industrial Accident Prevention Signs.

6. Ernest J. McCormick, Human Engineering, New York, McGraw-Hill Book Company, Inc., 1958, Page 375.

7. AMF Report, ER-TPS-206, Power Pack - Human Factors Review - Mandatory & Recommended Changes, 4/13/59.

8. AMF Report, ER-TPS-242, Air Conditioner vs Hydraulic Reservoir (T-2), 11/4/59.

# Chapter 18

## Human Factors Review and Evaluation of the Launcher Platform

## FAIL SAFE DESIGN

The "A" frame retraction jack cover can be screwed down only if the jacks have been removed; this insures that the jacks have been removed before the Launcher Platform is operated.

## SAFETY

Walking surfaces on the service platform are of a non-skid material.

Removable handrails have been provided on the service platforms.

A safety net has been permanently installed to prevent injury to personnel falling into the Flame Deflector.

## ACCESS

Access between the "A" frame and the Umbilical Tower should be adequate for the 95th percentile man.

Access to the Flame Deflector and launcher to crib seal deck have been provided.

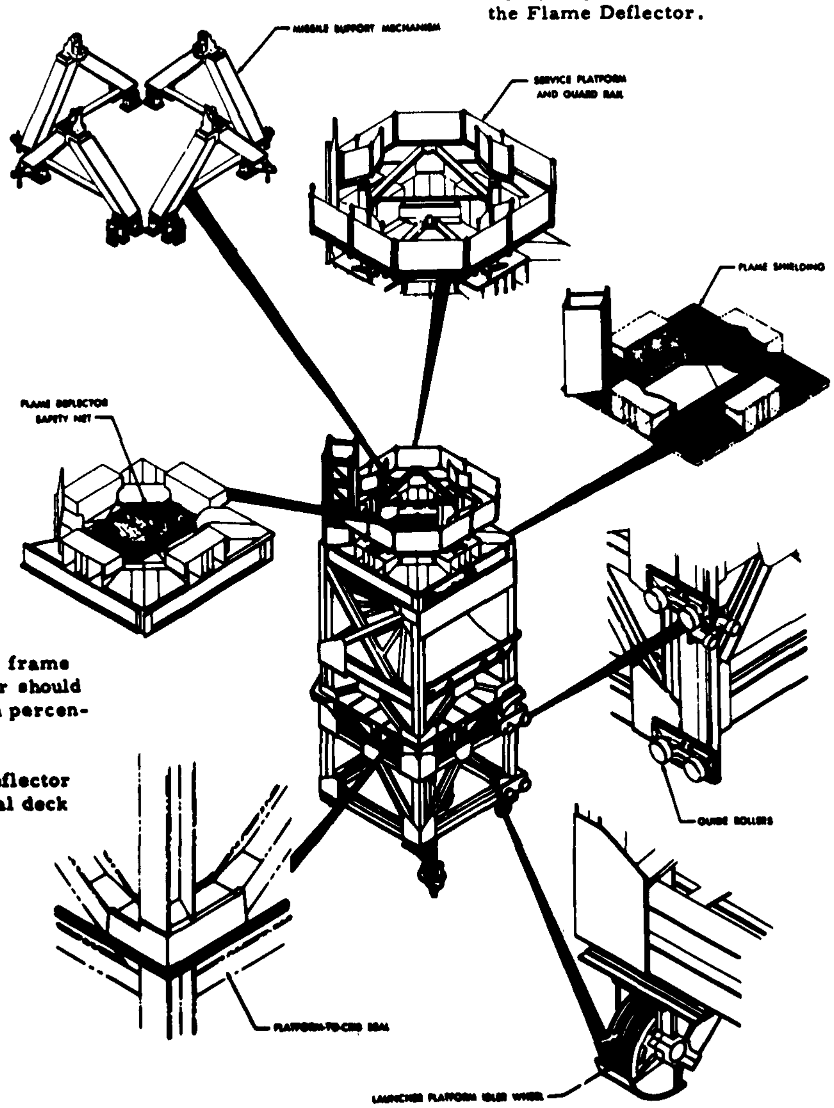



FIGURE 18-1
HUMAN FACTORS INPUTS
LAUNCHER PLATFORM

**SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO:**
LAUNCHER PLATFORM (EXCLUDING ACCESSORY EQUIPMENT)

| | | Human Factor Effort Required | Phase in Stage: Concept | Phase in Stage: Review | Phase in Stage: Analysis | Phase in Stage: Field Input | Human Factors Objective: Specification Compliance | Human Factors Objective: Safety | Human Factors Objective: Operational Status | Human Factors Objective: Maintenance Recommendation | Human Factors Objective: Product Improvement | Applicable on Model: OSTF | Applicable on Model: TF | Applicable on Model: OB | Symbol |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | **HUMAN ENGINEERING DESIGN FACTORS** | | | | | | | | | | | | | | |
| 1.1 | **Anthropometric Compatability** | * | | * | | | | * | | * | | * | * | | |
| 1.2 | **Controls and Displays** | | | | | | | | | | | | | | |
| 1.3 | **Fail-Safe Design** | * | | * | | | | * | | * | | * | * | | |
| 1.4 | **Malfunction Detection** | | | | | | | | | | | | | | |
| 2.0 | **MAINTENANCE FACTORS** | | | | | | | | | | | | | | |
| 2.1 | **Access, Visual** | | | | | | | | | | | | | | |
| 2.2 | **Access, Servicing** | * | | * | | | | * | | * | | * | * | | |
| 2.3 | **Remove and Replace** | * | | * | | | | * | | * | | * | * | | |
| 2.4 | **Handling, Physical Limitations** | | | | | | | | | | | | | | |
| 2.5 | **Handling, Transportation** | | | | | | | | | | | | | | |
| 2.6 | **Vehicle Maneuverability** | | | | | | | | | | | | | | |
| 3.0 | **SAFETY FACTORS** | | | | | | | | | | | | | | |
| 3.1 | **Chemical Decontamination** | | | | | | | | | | | | | | |
| 3.2 | **Escape Provisions** | | | | | | | | | | | | | | |
| 3.3 | **Protection from Entanglement** | | | | | | | | | | | | | | |
| 3.4 | **Protection from Falling** | * | | * | | | | * | | * | | * | * | | |
| 3.5 | **Safety Devices (other)** | | | | | | | | | | | | | | |
| 3.6 | **Warning Devices** | | | | | | | | | | | | | | |
| 4.0 | **PHYSIOLOGICAL FACTORS** | | | | | | | | | | | | | | |
| 4.1 | **Biological Damage** | | | | | | | | | | | | | | |
| 4.2 | **Vertigo** | | | | | | | | | | | | | | |
| 4.3 | **Vibration Effects** | | | | | | | | | | | | | | |
| 5.0 | **PSYCHOLOGICAL FACTORS** | | | | | | | | | | | | | | |
| 5.1 | **Fear of Heights** | | | | | | | | | | | | | | |
| 5.2 | **Fear of Being Crushed** | | | | | | | | | | | | | | |
| 5.3 | **Fear of Falling** | * | | * | | | | * | | * | | * | * | | |
| 5.4 | **Fear of Isolation** | | | | | | | | | | | | | | |
| 5.5 | **Feeling of Insecurity** | | | | | | | | | | | | | | |
| 6.0 | **ENVIRONMENTAL FACTORS** | | | | | | | | | | | | | | |
| 6.1 | **Acoustic Energy (noise)** | | | | | | | | | | | | | | |
| 6.2 | **Humidity & Temperature** | | | | | | | | | | | | | | |
| 6.3 | **Illumination** | | | | | | | | | | | | | | |
| 7.0 | HUMAN USE FACTORS | | | | | | | | | | | | | | |
| 7.1 | Procedure | | | | | | | | | | | | | | |
| 7.2 | Time Study | | | | | | | | | | | | | | |
| 7.3 | Training/Selection | | | | | | | | | | | | | | |

FIGURE 18-2

| SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO: LAUNCHER PLATFORM ACCESSORY EQUIPMENT | | | PHASE IN STAGE | | | | HUMAN FACTORS OBJECTIVE | | | | | APPLICABLE ON MODEL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Human Factor Effort Required | Concept | Review | Analysis | Field Input | Specification Complicance | Safety | Operational Status | Maintenance Recommendation | Product Improvement | OSTF | TF | OB | SYMBOL |
| | **1.0 HUMAN ENGINEERING DESIGN FACTORS** | | | | | | | | | | | | | | |
| **1.1** | **Anthropometric Compatability** | * | | * | | | | | * | | | * | * | |  |
| **1.2** | **Controls and Displays** | | | | | | | | | | | | | | |
| **1.3** | **Fail-Safe Design** | * | | * | | | | | * | | | * | * | | |
| **1.4** | **Malfunction Detection** | | | | | | | | | | | | | | |
| | **2.0 MAINTENANCE FACTORS** | | | | | | | | | | | | | | |
| **2.1** | **Access, Visual** | | | | | | | | | | | | | |  |
| **2.2** | **Access, Servicing** | | | | | | | | | | | | | | |
| **2.3** | **Remove and Replace** | * | | * | | | | | | * | | * | * | | |
| **2.4** | **Handling, Physical Limitations** | * | | * | | | | | | * | | * | * | | |
| **2.5** | **Handling, Transportation** | | | | | | | | | | | | | | |
| **2.6** | **Vehicle Maneuverability** | | | | | | | | | | | | | | |
| | **3.0 SAFETY FACTORS** | | | | | | | | | | | | | | |
| **3.1** | **Chemical Decontamination** | | | | | | | | | | | | | |  |
| **3.2** | **Escape Provisions** | | | | | | | | | | | | | | |
| **3.3** | **Protection from Entanglement** | | | | | | | | | | | | | | |
| **3.4** | **Protection from Falling** | * | | * | | | | * | | | | * | * | | |
| **3.5** | **Safety Devices (other)** | | | | | | | | | | | | | | |
| **3.6** | **Warning Devices** | | | | | | | | | | | | | | |
| | **4.0 PHYSIOLOGICAL FACTORS** | | | | | | | | | | | | | | |
| **4.1** | **Biological Damage** | | | | | | | | | | | | | |  |
| **4.2** | **Vertigo** | | | | | | | | | | | | | | |
| **4.3** | **Vibration Effects** | | | | | | | | | | | | | | |
| | **5.0 PSYCHOLOGICAL FACTORS** | | | | | | | | | | | | | | |
| **5.1** | **Fear of Heights** | | | | | | | | | | | | | |  |
| **5.2** | **Fear of Being Crushed** | | | | | | | | | | | | | | |
| **5.3** | **Fear of Falling** | | | | | | | | | | | | | | |
| **5.4** | **Fear of Isolation** | | | | | | | | | | | | | | |
| **5.5** | **Feeling of Insecurity** | | | | | | | | | | | | | | |
| | **6.0 ENVIRONMENTAL FACTORS** | | | | | | | | | | | | | | |
| **6.1** | **Acoustic Energy (noise)** | | | | | | | | | | | | | |  |
| **6.2** | **Humidity & Temperature** | | | | | | | | | | | | | | |
| **6.3** | **Illumination** | * | | | | * | | | * | | | * | * | | |
| | 7.0 HUMAN USE FACTORS | | | | | | | | | | | | | | |
| 7.1 | Procedure | | | | | | | | | | | | | |  |
| 7.2 | Time Study | | | | | | | | | | | | | | |
| 7.3 | Training/Selection | | | | | | | | | | | | | | |

FIGURE 18-3

## 1.0 DESCRIPTION

1.1 In this chapter the human factors will be considered which are pertinent to the design and installation of the Launcher Platform and its accessory equipment.

### 1.1.1 Launcher Platform (Excluding Accessory Equipment)

### 1.1.2 Description of Launcher Platform (Excluding Accessory Equipment)

The Launcher Platform is the missile supporting structure in all cycles. It is mounted within guide rails on rollers and is the elevating platform for raising and lowering the missile between the storage position and the launching position.

The Launcher Platform provides a common framework for attachment and support of the following major components:

1. Service Platform
2. Missile Support System
3. Flame Shielding
4. Missile Support System Pedestal
5. Flame Deflector Cooling Spray System
6. Flame Deflector

   Flame Deflector Extension

8. Platform-to-Crib Lock Brackets
9. Guide Roller Assembly
10. Idler Sheaves
11. Water Connection System
12. Platform-to-Crib Seal
13. Launcher Platform Structure
14. Engine Compartment Water Spray System
15. Umbilical Tower Base

1.1.3 Applicable Human Factors Considerations for Launcher Platform (Excluding Accessory Equipment)

The Launcher Platform must be designed for operation by Air Force personnel between the 5th and 95th percentile. Adequate work space must be provided for personnel who service the unit. All components must be accessible for maintenance. Fail safe design features should be provided whenever serious damage to the Launcher Platform equipment is possible. Consideration should be given to skid-proof flooring.

1.2 Launcher Platform Accessory Equipment

1.2.1 Description of Launcher Platform Accessory Equipment

The Launcher Platform accessory equipment includes the Engine Maintenance Stands and the Igniter Maintenance Stands. These stands are used to perform maintenance on the missile and are removable. The stands are of an aluminum tubular truss construction.

1.2.2 Applicable Human Factors Considerations for Launcher Platform Accessory Equipment

The accessory equipment must be designed for operation by Air Force personnel between the 5th and 95th percentile. The stands must be designed so that they can be put in place and removed safely and efficiently. They should provide proper access to the missile components. The necessary guard rails should be provided to protect the operators from falling.

ITEM: LAUNCHER PLATFORM ( EXCLUDING ACCESSORY EQUIPMENT)

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: CONTRACTUAL AFBM 57-8A | DOCUMENTARY COMPLIANCE: TECH. REF. | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION: ANAL | VERIFICATION: EQUIP | VERIFICATION: TEST | RESULTS | RELATIVE VALUE % |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 HUMAN ENGINEERING DESIGN FACTORS | | | | | | | | | | |
| 1.1 ANTHROPOMETRIC COMPATABILITY | 6.1.1 | WADC TR 52-321 | THE MINIMUM DIMENSIONS FOR PASSING BODY THICKNESS IS 13 INCHES. | THE SPACE BETWEEN THE "A" FRAME AND THE UMBILICAL TOWER AT WAIST HEIGHT ON THE SERVICE PLATFORM IS 11.9 INCHES. | THIS DISTANCE SHOULD BE INCREASED TO 13 INCHES SO THAT THE OPERATOR WILL NOT BE REQUIRED TO WALK AROUND THE MISSILE TO REACH THE OTHER SIDE OF THE UMBILICAL TOWER. | X | | | THE OVERALL SPACE LIMITATIONS PREVENTED AN INCREASE IN THIS DIMENSION. | 25 |
| 1.3 FAIL SAFE DESIGN | 1.4 | | ALL REASONABLE EFFORT SHOULD BE DIRECTED TO ACHIEVE A FAIL-SAFE DESIGN IN THOSE AREAS WHERE HIGH RELIABILITY CANNOT BE EXPECTED AND THE CONSEQUENCES OF FAILURE MAY RESULT IN THE DESTRUCTION OF EQUIPMENT OR INJURY TO PERSONNEL. | DAMAGE CAN RESULT IF AN ATTEMPT IS MADE TO OPERATE THE LAUNCHER PLATFORM WITHOUT FIRST REMOVING THE JACKS FOR THE MISSILE SUPPORT MECHANISM. | IT WAS RECOMMENDED THAT EITHER (A) A REMOVABLE PLUG BE PROVIDED IN THE COVER FOR VISUAL ACCESS, (B) THE COVER BE DESIGNED SO THAT IT CANNOT BE CLOSED UNTIL THE JACKS ARE REMOVED, OR (C) THE JACKS BE LOCATED UNDERNEATH THE FLAME SHIELD. | X | | | PROCEDURE WAS CHANGED TO ELIMINATE PROBLEM. COVER CAN BE SCREWED DOWN ONLY WHEN JACK IS REMOVED. | 30 |
| 2.0 MAINTENANCE FACTORS | | | | | | | | | | |
| 2.2 ACCESS, SERVICING | 4.3.2.3.1 | | IT SHOULD BE POSSIBLE TO USE REQUIRED TOOLS WITHOUT DIFFICULTY OR HAZARD. | TITAN CHANGE REQUEST DATED 5/26/60. | THE AIR LINE TAP IN THE SILO SHOULD BE MADE AVAILABLE AT EACH PLATFORM LEVEL FOR USE IN CLEANING OR USING AIR TOOLS. | X | | | DESIGN CHANGES IN TORQUING TOOL ELIMINATED THIS REQUEST. | 30 |
| | 4.2.1 | | UNITIZATION IS ONE OF THE GENERAL PRINCIPLES OF EQUIPMENT DESIGN FOR MAINTAINABILITY. UNITIZATION REQUIRES THAT EQUIPMENT BE DESIGNED TO PROVIDE FOR RAPID AND EASY SERVICE OF UNITS BY A SINGLE OPERATOR, IF POSSIBLE. | PARAGRAPH 3.1 OF DESIGN SPECIFICATION ADS-20188, DATED JUNE 24, 1959 | THE SERVICE PLATFORM SHOULD PROVIDE ACCESS FOR SERVICING THE STAGE I UMBILICALS AND MISSILE SUPPORT ARMS WITHIN ELEVATIONS 307' 5.25" THROUGH 314', THE MAIN FUEL CONNECTIONS, AND LIQUID OXYGEN MECHANISMS AND CONNECTIONS. | | | | ACCESS IS STILL A PROBLEM | 30 |

2.0 SYNOPSIS

ITEM: LAUNCHER PLATFORM (EXCLUDING ACCESSORY EQUIPMENT)

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: CONTRACTUAL AFBM 57-9A | DOCUMENTARY COMPLIANCE: TECH REF. | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION: ANAL | VERIFICATION: EQUIP | VERIFICATION: TEST | RESULTS | RELATIVE VALUE % |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.3 REMOVE - REPLACE | 4.2.1 | | EQUIPMENT SHOULD BE DESIGNED TO PROVIDE FOR RAPID AND EASY REMOVAL AND REPLACEMENT OF UNITS BY A SINGLE OPERATOR. | AMF DOCUMENT TS 7.2.38, 4/1/60. | RECOMMENDATIONS WERE MADE FOR THE INSTALLATION OF THE UMBILICAL TOWER ACTUATOR CYLINDER. THE RECOMMENDATIONS ARE DESCRIBED IN DETAIL IN THE AMF DOCUMENT. | X | | | NO SPECIAL PROBLEMS IN INSTALLATION OF CYLINDER. | 15 |
| 3.0 SAFETY FACTORS<br>3.4 PROTECTION FROM FALLING | 7.22 | PAR. 5.3.3.4 OF CHAPTER 5 IN VOLUME I OF ARDCM MANUAL 80-6. | PROVIDE SKID PROOF FLOORING. | PARAGRAPH 3.5 OF DESIGN SPECIFICATION ADS-20180, DATED JUNE 24, 1959. | THE DESIGN OF THE SERVICE PLATFORM SHOULD PROVIDE FOR NON-SKID WALKING SURFACES EITHER BY STRUCTURAL DESIGN OR THE APPLICATION OF A CONDUCTIVE NON-SKID MATERIAL. | X | | | REQUIREMENT SATISFIED. NON-SKID MATERIAL. | 20 |
| | | | | | | | | | | 100 |

2.0 SYNOPSIS

ITEM: LAUNCHER PLATFORM ACCESSORY EQUIPMENT

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE | | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA | | VERIFICATION | | | RESULTS | % RELATIVE VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| | CONTRACTUAL AFBM 57-8A | TECH REF. | | PARTICIPATION | RECOMMENDATIONS | ANAL | EQUIP | TEST | | |
| 1.0 HUMAN ENGINEERING DESIGN FACTORS<br>1.1 ANTHROPOMETRIC COMPATABILITY | 6.1.1 | | THE MINIMUM OVERHEAD HEIGHT FOR STANDING POSITION IS 73 INCHES. | SERVICE PLATFORM NUMBER 6 IS 4' 4.6" ABOVE THE MAINTENANCE STAND AND THE MISSILE SKIRT IS 5' ABOVE THE MAINTENANCE STAND. AS A RESULT THE HEADROOM IS INADEQUATE AT THE POINT WHERE THE SERVICE PLATFORM AND SKIRT ARE DIRECTLY OVER THE STAND. | EITHER THE EQUIPMENT SHOULD BE REDESIGNED TO PERMIT MORE HEADROOM OR WARNING SIGNS SHOULD BE PROVIDED. | X | | | THE HEADROOM CANNOT BE IMPROVED DUE TO THE ADVANCED DESIGN OF THE LAUNCHER PLATFORM. | 10 |
| 1.3 FAIL SAFE DESIGN | 1.4 | | ALL REASONABLE EFFORT SHOULD BE DIRECTED TOWARD THE ACHIEVEMENT OF A FAIL-SAFE DESIGN IN THOSE AREAS WHERE HIGH RELIABILITY CANNOT BE EXPECTED AND THE CONSEQUENCES OF FAILURE COULD RESULT IN DAMAGE TO EQUIPMENT OR INJURY TO PERSONNEL. | THE SUPPORT FOR THE IGNITOR MAINTENANCE STAND SHOULD BE SECURE UNDER ALL OPERATING CONDITIONS. | A FAIL-SAFE CLAMPING DEVICE SHOULD BE PROVIDED. | X | | | THE CLAMPING DEVICE PROVIDED IS A FAIL-SAFE DEVICE. | 15 |
| 2.0 MAINTENANCE FACTORS<br>2.3 HANDLING, REMOVE AND REPLACE | 4.2.1 | | ALL EQUIPMENT SHOULD BE DESIGNED SO THAT INSTALLATION AND REMOVAL CAN BE ACCOMPLISHED RAPIDLY AND EASILY. | TWO ADJACENT MAINTENANCE STANDS MUST BE INSTALLED TOGETHER TO PROVIDE SUFFICIENT STRUCTURAL SUPPORT. AS A RESULT THE ACCESS ROOM IS SEVERELY LIMITED. | MODIFICATIONS WERE RECOMMENDED TO INCREASE THE AVAILABLE AREA. | X | | | NO ADDITIONAL ACCESS ROOM COULD BE PROVIDED AT TF-1. | 15 |

2.1 SYNOPSIS

ITEM: LAUNCHER PLATFORM ACCESSORY EQUIPMENT

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: CONTRACTUAL AFBM 57-8A | DOCUMENTARY COMPLIANCE: TECH. REF. | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION: ANAL | VERIFICATION: EQUIP | VERIFICATION: TEST | RESULTS | % RELATIVE VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.3 HANDLING, REMOVE AND REPLACE (CONT'D) | 4.3.3.3 | | UNITS DESIGNED FOR REMOVAL AND REPLACEMENT SHOULD BE PROVIDED WITH HANDLES OR OTHER SUITABLE PROVISIONS FOR GRASPING, HANDLING, AND CARRYING. | [illegible]-5015 B MEANS SHOULD BE PROVIDED ON ALL WORK STAND SECTIONS FOR EASY AND RAPID HANDLING. | THE TUBULAR CONSTRUCTION OF THE STANDS OFFERS A SATISFACTORY SUBSTITUTE FOR HANDLES. | X | | | NOT APPLICABLE | 10 |
| 2.4 HANDLING, PHYSICAL LIMITATIONS | 4.3.3.1 | | THE WEIGHT OF A UNIT MUST BE CONSIDERED TO INSURE ITS PORTABILITY BY ONE OR TWO MEN. | THE ENGINE MAINTENANCE STANDS VARY IN WEIGHT FROM 72 TO 95 POUNDS. THE IGNITER MAINTENANCE STAND WEIGHS 130 POUNDS BUT IS EQUIPPED WITH CASTERS. | THE WEIGHT OF THE STANDS IS NOT EXCESSIVE. | X | | | NOT APPLICABLE | 10 |
| 3.0 SAFETY FACTORS<br>3.4 PROTECTION FROM FALLING | 7.8 | | PROVIDE PROTECTION SUCH AS STAIRS, AND AROUND FLOOR OPENINGS OR WHEREVER PERSONNEL MAY FALL FROM AN ELEVATION. | [illegible] 5015 B | KICKPLATES WERE RECOMMENDED FOR THE VARIOUS STANDS. HANDRAILS WERE RECOMMENDED FOR THE IGNITER MAINTENANCE STAND. | X | | | KICKPLATES AND HANDRAILS HAVE BEEN PROVIDED. | 15 |
| | | | | [illegible]-1061 | IT WAS RECOMMENDED THAT THE FLAME DEFLECTOR SAFETY NET BE PERMANENTLY INSTALLED. | X | | | NOT ADOPTED | 15 |
| 6.0 ENVIRONMENTAL FACTORS<br>6.3 ILLUMINATION | 7.21 | | ADEQUATE ILLUMINATION SHOULD BE PROVIDED IN ALL WORK AREAS. | ILLUMINATION IN THE AREA OF THE LAUNCHER PLATFORM IS AS LOW AS 5 FT. CANDLES. | HUMAN FACTORS RECOMMENDED THAT THE LIGHTING IN THE SILO BE REVISED. A STUDY IS TO BE CARRIED OUT BY THE MARTIN COMPANY. | | X | X | LIGHTING IS NOT ADEQUATE | 10 |
| | | | | | | | | | | 100 |

2.1 SYNOPSIS

## 3.0 DISCUSSION

Consideration should be given to those areas of interface between the missile and launcher that may require special tooling or methods. One prime area for product improvement is the method of installation and torquing of the explosive hold down bolts. Because of limited accessibility, special pneumatic tools should be used wherever possible to permit installation by the minimum number of personnel.

## 4.0 REFERENCES


1. AFBM Exhibit 57-8A, Human Engineering Design Standards for Missile System Equipment.
2. ARDCM 80-6, Handbook of Instructions for Aircraft Ground Support Equipment Designers.
3. WADC TR 52-321, Anthropometry of Flying Personnel.
4. ADS-1003C, Personnel Safety for WS 107A-2 Launcher System.
5. ADS-2018B, Service Platform for WS 107A-2 Launcher System.
6. ADS-5015B, Silo Mouth Platforms, Accessory Work Stand, and Stage I and Stage II Tail Access Work Stands for WS 107A-2 Launcher System.
7. AMF Drawing No. HF-T-1061, Stage I Engine Access Safety Net Study.
8. AMF Document TS 7.2.40, Titan Change Request.

# Chapter 19

## Human Factors Review and Evaluation of the Logic System & Test Equipment

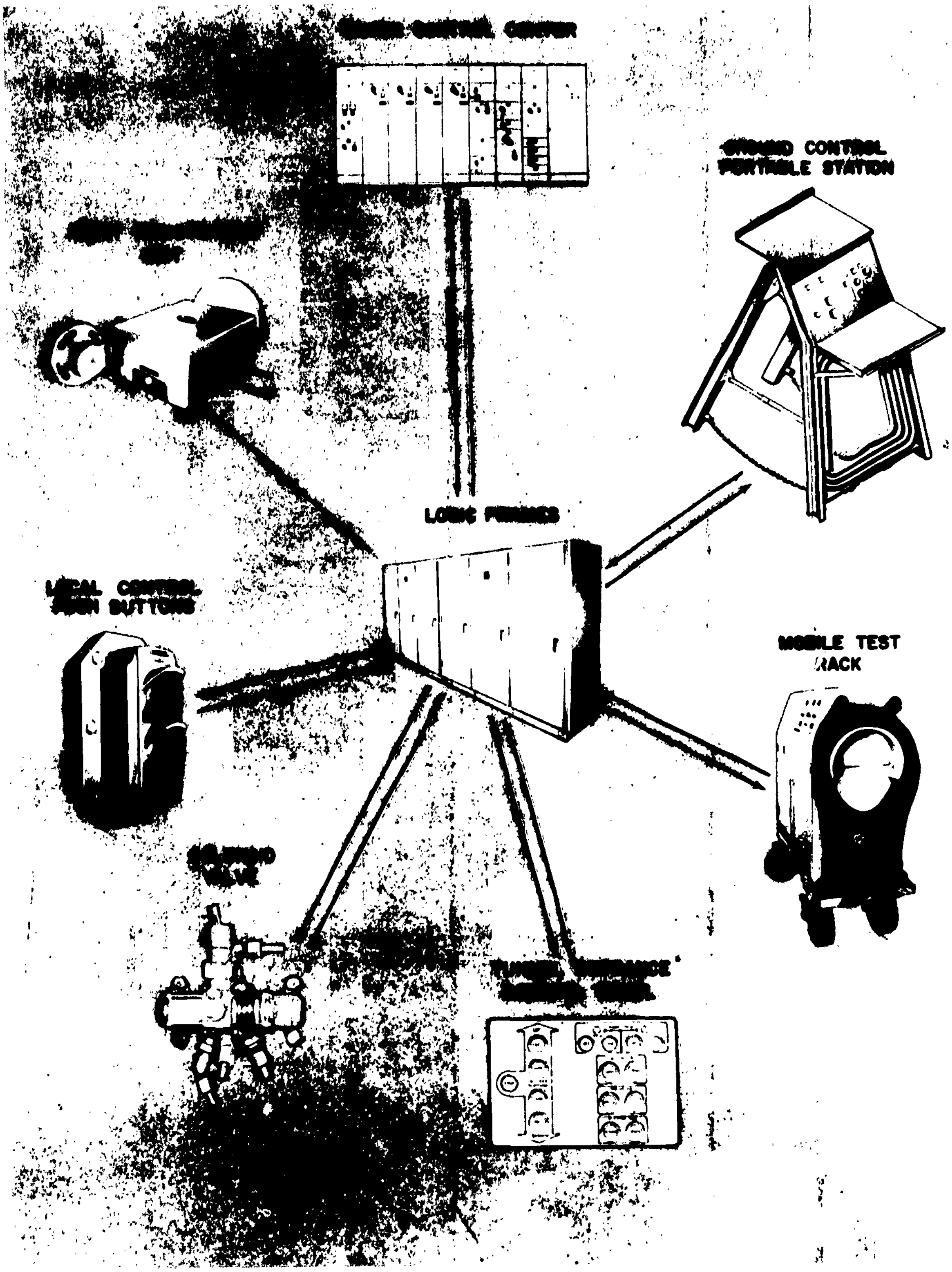




FIGURE 19-1
LOGIC SYSTEM

FAIL-SAFE

System is fail-safe.

FAULT DETECTION

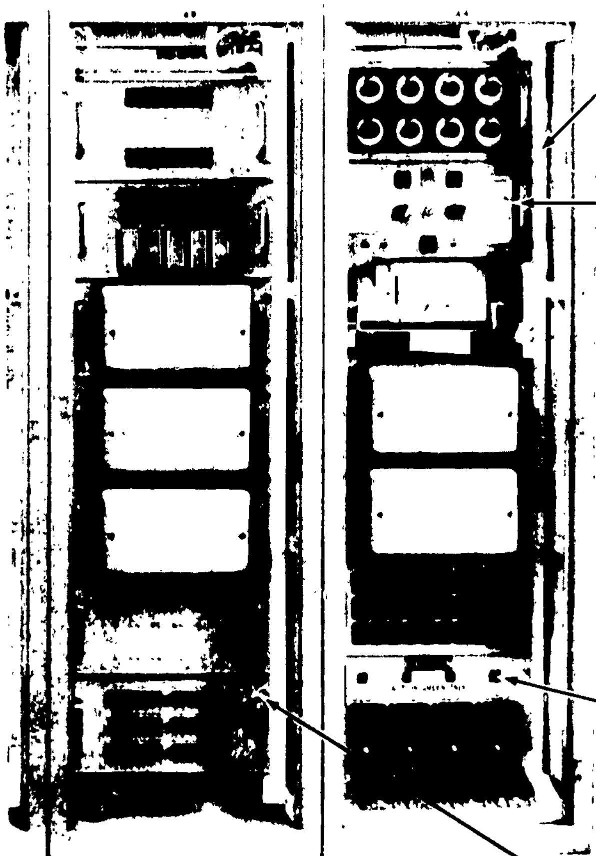
Fault indications should be reduced to a single malfunction and readouts should be simple to decode.

PANEL LOCATION

Panel has been located within optimum area.

PANEL ARRANGEMENT

Controls and displays have been arranged to reduce operating time and to reduce probability of accidental activation.



WARNING DEVICES

Transilluminated displays indicate safe condition for connection and disconnection of plugs.

GROUNDING

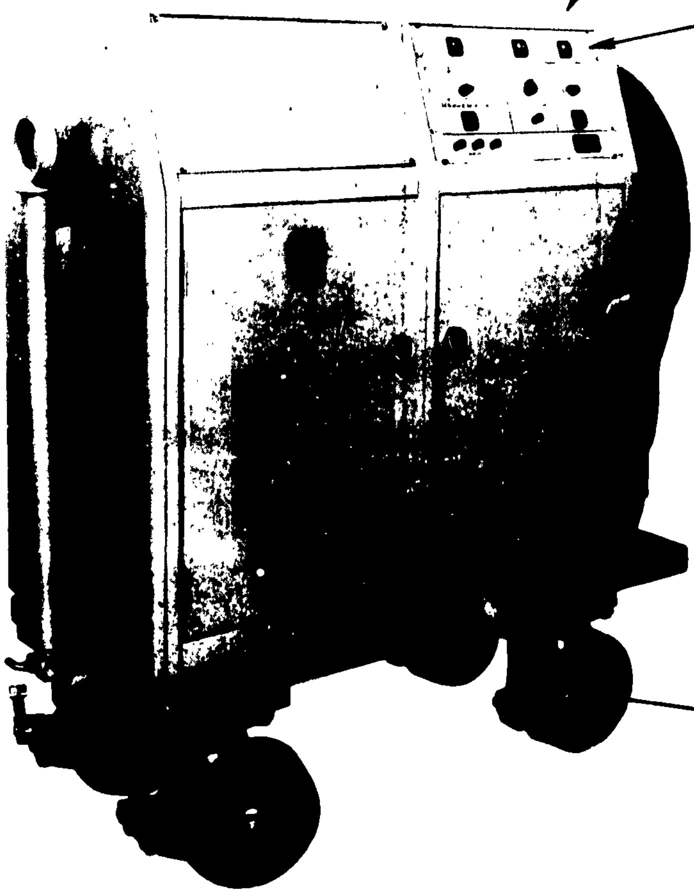
A grounded system has been provided.

REMOVE AND REPLACE

Factors contributing to safe and efficient removal and replacement of modules have been included: coding, handles, quick release fasteners, weights.

FIGURE 19-2

HUMAN FACTORS INPUTS
LOGIC RACK



CONTROL SURFACE

Surface has been slanted to improve vision and control actuation.

PANEL ARRANGEMENT

Controls and displays have been arranged for optimum use.

REMOVE AND REPLACE

Factors contributing to safe and efficient removal and replacement of modules have been included: coding, handles, quick release fasteners, weights.

WHEEL BRAKES

Static wheel brakes have been provided.

VEHICLE MANEUVERABILITY

Size and weight limit vehicle portability.

19-3

FIGURE 19-3
HUMAN FACTORS INPUTS
MOBILE TEST RACK

SUMMARY CHECKLIST OF
HUMAN FACTORS PROGRAM
IN RELATION TO:

LOGIC RACK

| No. | Item | Human Factor Effort Required | Phase in Stage: Concept | Phase in Stage: Review | Phase in Stage: Analysis | Phase in Stage: Field Input | Human Factors Objective: Specification Compliance | Human Factors Objective: Safety | Human Factors Objective: Operational Status | Human Factors Objective: Maintenance Recommendation | Human Factors Objective: Product Improvement | Applicable on Model: OSTF | Applicable on Model: TF | Applicable on Model: OS | Symbol |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | HUMAN ENGINEERING DESIGN FACTORS | | | | | | | | | | | | | |  |
| 1.1 | Anthropometric Compatability | * | * | * | | | * | | * | | | * | * | * | |
| 1.2 | Controls and Displays | * | * | * | | | * | | * | | | * | * | * | |
| 1.3 | Fail-Safe Design | * | | | * | | * | * | | | | * | * | * | |
| 1.4 | Malfunction Detection | * | | | * | | * | | * | * | | * | * | * | |
| 2.0 | MAINTENANCE FACTORS | | | | | | | | | | | | | |  |
| 2.1 | Access, Visual | * | * | * | | | * | | | * | | * | * | * | |
| 2.2 | Access, Servicing | | | | | | * | | | | | | | | |
| 2.3 | Remove and Replace | * | * | * | | | * | | | * | | * | * | * | |
| 2.4 | Handling, Physical Limitations | * | * | * | | | * | | | * | | * | * | * | |
| 2.5 | Handling, Transportation | | | | | | | | | | | | | | |
| 2.6 | Vehicle Maneuverability | | | | | | | | | | | | | | |
| 3.0 | SAFETY FACTORS | | | | | | | | | | | | | |  |
| 3.1 | Chemical Decontamination | | | | | | | | | | | | | | |
| 3.2 | Escape Provisions | | | | | | | | | | | | | | |
| 3.3 | Protection from Entanglement | | | | | | | | | | | | | | |
| 3.4 | Protection from Falling | | | | | | | | | | | | | | |
| 3.5 | Safety Devices (other) | * | * | * | * | | | * | | * | | * | * | * | |
| 3.6 | Warning Devices | * | * | * | * | | | * | | * | | * | * | * | |
| 4.0 | PHYSIOLO[illegible]L FACTORS | | | | | | | | | | | | | |  |
| 4.1 | Biological Da[illegible] | | | | | | | | | | | | | | |
| 4.2 | Vertigo | | | | | | | | | | | | | | |
| 4.3 | Vibration Effects | | | | | | | | | | | | | | |
| 5.0 | PSYCHOLOGICAL FACTORS | | | | | | | | | | | | | |  |
| 5.1 | Fear of Heights | | | | | | | | | | | | | | |
| 5.2 | Fear of Being Crushed | | | | | | | | | | | | | | |
| 5.3 | Fear of Falling | | | | | | | | | | | | | | |
| 5.4 | Fear of Isolation | | | | | | | | | | | | | | |
| 5.5 | Feeling of Insecurity | | | | | | | | | | | | | | |
| 6.0 | ENVIRONMENTAL FACTORS | | | | | | | | | | | | | |  |
| 6.1 | Acoustic Energy (noise) | | | | | | | | | | | | | | |
| 6.2 | Humidity & Temperature | | | | | | | | | | | | | | |
| 6.3 | Illumination | | | | | | | | | | | | | | |
| 7.0 | HUMAN USE FACTORS | | | | | | | | | | | | | |  |
| 7.1 | Procedure | | | | | | | | | | | | | | |
| 7.2 | Time Study | | | | | | | | | | | | | | |
| 7.3 | Training/Selection | | | | | | | | | | | | | | |

FIGURE 19-4

**SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO:**

**MOBILE TEST RACK**

| No. | Item | Human Factor Effort Required | Phase in Stage: Concept | Review | Analysis | Field Input | Human Factors Objective: Specification Compliance | Safety | Operational Status | Maintenance Recommendation | Product Improvement | Applicable on Model: OSTF | TF | OB | Symbol |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | HUMAN ENGINEERING DESIGN FACTORS | | | | | | | | | | | | | | |
| 1.1 | Anthropometric Compatability | * | | * | | | * | | * | | | * | | | |
| 1.2 | Controls and Displays | * | | * | | | * | | * | | | * | | | |
| 1.3 | Fail-Safe Design | * | | | * | | | * | | | | * | | | |
| 1.4 | Malfunction Detection | | | | | | | | | | | | | | |
| 2.0 | MAINTENANCE FACTORS | | | | | | | | | | | | | | |
| 2.1 | Access, Visual | * | | * | | | * | | | * | | * | | | |
| 2.2 | Access, Servicing | * | | * | | | * | | | * | | * | | | |
| 2.3 | Remove and Replace | * | | * | | | * | | | * | | * | | | |
| 2.4 | Handling, Physical Limitations | * | | * | | | * | | | * | | * | | | |
| 2.5 | Handling, Transportation | | | | | | | | | | | | | | |
| 2.6 | Vehicle Maneuverability | * | | * | | | * | | | * | | * | | | |
| 3.0 | SAFETY FACTORS | | | | | | | | | | | | | | |
| 3.1 | Chemical Decontamination | | | | | | | | | | | | | | |
| 3.2 | Escape Provisions | | | | | | | | | | | | | | |
| 3.3 | Protection from Entanglement | | | | | | | | | | | | | | |
| 3.4 | Protection from Falling | | | | | | | | | | | | | | |
| 3.5 | Safety Devices (other) | * | | * | | | * | * | | | | * | | | |
| 3.6 | Warning Devices | | | | | | | | | | | | | | |
| 4.0 | PHYSIOLOGICAL FACTORS | | | | | | | | | | | | | | |
| 4.1 | Biological Damage | | | | | | | | | | | | | | |
| 4.2 | Vertigo | | | | | | | | | | | | | | |
| 4.3 | Vibration Effects | | | | | | | | | | | | | | |
| 5.0 | PSYCHOLOGICAL FACTORS | | | | | | | | | | | | | | |
| 5.1 | Fear of Heights | | | | | | | | | | | | | | |
| 5.2 | Fear of Being Crushed | | | | | | | | | | | | | | |
| 5.3 | Fear of Falling | | | | | | | | | | | | | | |
| 5.4 | Fear of Isolation | | | | | | | | | | | | | | |
| 5.5 | Feeling of Insecurity | | | | | | | | | | | | | | |
| 6.0 | ENVIRONMENTAL FACTORS | | | | | | | | | | | | | | |
| 6.1 | Acoustic Energy (noise) | | | | | | | | | | | | | | |
| 6.2 | Humidity & Temperature | | | | | | | | | | | | | | |
| 6.3 | Illumination | | | | | | | | | | | | | | |
| 7.0 | HUMAN USE FACTORS | | | | | | | | | | | | | | |
| 7.1 | Procedure | | | | | | | | | | | | | | |
| 7.2 | Time Study | | | | | | | | | | | | | | |
| 7.3 | Training/Selection | | | | | | | | | | | | | | |

FIGURE 19-5

## 1.0 DESCRIPTION

1.1 In this chapter, the human factors will be considered which are pertinent to the design of the logic system including the Logic Racks and the Mobile Test Rack. The logic system provides sequential control for each equipment operation within the launcher system. The Launch Controller in the Command Control Center furnishes command signals to initiate each sequence. At the completion of a sequence, limit switches within the launcher system close and provide return signals to the Launch Controller logic system. These signals indicate the action has been completed and the next step can be started. No human inputs are required during the full automatic cycling of the launcher. Individual sub-systems can also be operated by the logic system. In this mode, push buttons at the local control station are used by an operator to provide the appropriate command signals to the logic system.

The Launch Controller also furnishes time check signals to monitor the system response. A system malfunction or a sequence which is not completed within the required time causes the system to shut down. The launcher is then returned through the reverse cycle to its hard state position.

In order to provide maintenance crews with the information they must have regarding the exact description and location of a malfunction, the logic system has been connected to additional circuitry which detects, locates and records malfunctions. The circuitry operates only if the logic system is exercised. Should a fault occur while the launcher is being controlled by the Launch Controller, the entire system will shutdown and a fault tape will be punched describing the function which failed, the type of failure, and the location (launcher components or relays).

If at any time, maintenance crews wish to obtain additional tape readings without exercising the entire system they may do so by following a simulated test procedure, using special equipment which simulates Launch Controller commands and launcher component responses from the Operating Test Control Panel. During this procedure the launcher components are disconnected from the logic system and the fault tape can be used to detect faults within the relay system. A Fault Test Program has also been provided to check out the operability of the fault detection and recording system.

The simulating circuitry can be used while the logic system is connected to the launcher components to exercise the actual launcher from the Operating Test Control Panel. All sequences expect firing and water spray can be exercised in this manner.

At the TF installation, the logic circuitry, the fault detection circuitry, and the test equipment are all located in the Logic Racks. The logic system at the OSTF installation is of the same design as at TF with the exception that the test equipment is located in a Mobile Test Rack.

### 1.2 Description of Logic Racks for TF & OB Installations

The Logic Racks provide a central location for the chassis which contain the logic system components such as the circuit breakers, relays, timers, counters, and connectors. Frames serve as structural elements to support the individual chassis, the connector strips, and the panels, which make up the back sides and doors. Separate covers, equipped with quick release fasteners, protect the relays mounted on each chassis.

In TF and in all OB installations the Directory Panel and the Operating Test Control Panel are integrated into one compartment of the Logic Racks along with the fault readout (tape punch) and the Connector Chassis.

1.2.1 Applicable Human Factor Considerations for the Logic Racks

The Logic Racks must be designed for operation by Air Force personnel between the 5th and 95th percentile. Controls on the operating panel must be located so as to reduce the probability of operator error and the system must be interlocked against damage from any human error which might occur. The fault detection circuitry should enable the operator to check the equipment prior to and during operation, localize faults to single components, and check the fault detection circuitry itself. Design techniques should be used to simplify the maintenance task.

Factors contributing to the successful use of the Logic Racks have been itemized on the Summary Checklist (Fig. 19-4) and the progress of the equipment design has been tabulated in detail in the following Synopsis.

## 1.3 Description of Mobile Test Rack for OSTF Only

The Function Blocks (relay sub-system) located within the Logic Racks require the following signals in order to perform any exercise.

1. Limit switch closures within the Launcher: The limit switch closures provide "action completed" signals to the Function Relays (within the Logic Chassis) which in turn provide the signal required to start the next step in the sequence.
2. Command signals from the Launch Controller (located in the Command Control Center): These signals start each sequence in the operation.
3. Time monitoring signals from the Launch Controller (located in the Command Control Center); These signals are sent when the time interval for each sequence is completed. They are used by the AMF Launcher Controller to detect, locate, and register a fault and produce a Launcher NO - GO signal if the "sequence completed" signal is not sent.

The Fault Detection and Readout System will detect or record a malfunction only when the Function Blocks are exercised in some way. In order to exercise these Function Blocks while the Launcher lies dormant in the hard state, it is necessary to simulate the above mentioned signals.

The Mobile Test Rack provides a movable housing for the equipment necessary to provide these signal simulations. For a complete description of this equipment in its relationship to the Logic Racks as well as the human operator refer to the "Man-Machine Analysis of the Portable Test Rack" in the Appendix, Vol. III. An explanation of the 3 volt system used in test procedures is also provided.

1.3.1 Applicable Human Factor Considerations for the OSTF Mobile Test Rack

The OSTF Mobile Test Rack must be designed for operation by Air Force personnel between the 5th and 95th percentile. In order to accomplish this end the following human factors criteria should be considered:

1. Portability - unit should be limited in size and weight to allow for easy handling through doorways, corridors, tunnels, and on ramps, and on elevators.
2. Control and display area - The control and display surface should slant away from the operator so that the center of the panel is perpendicular to the operator's standing line of sight (optimum for 50th percentile). The front edge of this surface should be at an optimum height for an operator in the 5th percentile).
3. Locking wheels - All wheels or castors should be of the locking type so that unit may be secured during operation and while in storage.
4. Indicator lights - Colors must be compatible with designations used throughout the system.
5. Component replacement - Components should be removable without the necessity of removing other components or equipment.
6. Operator compatibility - Any operators with a basic understanding of the system should be able to make optimum use of this test equipment without making human input errors. In order to accomplish this, the selection and placement of control and displays should be based upon the operator's input-output requirements as the human component in the system.

**ITEM:** LOGIC RACK

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE | | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA | | VERIFICATION | | | RESULTS | RELATIVE VALUE % |
|---|---|---|---|---|---|---|---|---|---|---|
| | CONTRACTUAL AFBM 57-8A | TECH REF. | | PARTICIPATION | RECOMMENDATIONS | ANAL. | EQUIP. | TEST | | |
| 1.0 HUMAN ENGINEERING DESIGN FACTORS<br>1.1 ANTHROPOMETRIC COMPATABILITY | PAR. 6.1.1 | HUMAN ENGINEERING HANDBOOK | CONTROL PANEL SHOULD BE BETWEEN 60.3" AND 69.1" ABOVE THE GROUND TO INCLUDE 95 % OF THE POPULATION. | DRAWING REVIEW AND DESIGN CONFERENCES. | CONTROL PANEL LOCATION IN ACCORDANCE WITH REFERENCE WAS RECOMMENDED. | X | X | | RECOMMENDATIONS ADOPTED. | 5 |
| 1.2 CONTROLS AND DISPLAYS | PAR. 3.1.3<br><br>PAR. 3.1.4<br><br>PAR. 3.2.1<br>PAR. 3.2.4<br><br>PAR. 2.1.1 | | 1. LOCATE AND DESIGN CONTROLS TO REDUCE PROBABILITY OF ACCIDENTAL ACTIVATION.<br>2. ARRANGE CONTROLS TO REDUCE OPERATING TIME AND ERROR PROBABILITY.<br>3. SPECIFIC REQUIREMENTS FOR PUSH BUTTONS ARE DETAILED.<br>4. SPECIFIC REQUIREMENTS FOR ROTARY SELECTOR SWITCHES ARE DETAILED.<br>5. DISPLAY DATA SHOULD BE PRESENTED IN A DIRECTLY USABLE FORM TO MINIMIZE REQUIREMENTS FOR DECODING AND INTERPOLATION. | DRAWING REVIEWS AND DESIGN CONFERENCES.<br>AMF, TECHNICAL BULLETIN #72 21 APRIL 1958 PROVIDED INFORMATION ON PANEL FRONT LAYOUT. | RECOMMENDATIONS ON CONTROL LAYOUT WERE MADE IN ACCORDANCE WITH AFBM 57-8A.<br>PRINTER DATA IS DISPLAYED IN EIGHT COLUMNS. THE CHANNEL INPUTS HAVE BEEN ASSIGNED SO THAT THE OPERATOR MUST READ FROM RIGHT TO LEFT. THIS ARRANGEMENT INCREASES READING TIME AND ERROR PROBABILITY. HUMAN FACTORS RECOMMENDED CHANNEL INPUTS BE SELECTED SO PRINTER CAN BE READ FROM LEFT TO RIGHT. | | X | | THE CONTROL AND DISPLAY AREAS FOR THE OPERATING TEST PANEL AND THE CIRCUIT BREAKER PANEL MEET REQUIREMENTS. THE FAULT READOUT PRINTER STILL REQUIRES THE OPERATOR TO READ THE COLUMNS FROM RIGHT TO LEFT. | 10 |
| 1.3 FAIL SAFE DESIGN | PAR. 1.4 | | EFFORT SHOULD BE MADE TO ACHIEVE A FAIL SAFE DESIGN. SYSTEM SHOULD BE SAFE FROM HUMAN INITIATED ERRORS. | REVIEW OF ELECTRICAL SCHEMATICS TO DETERMINE THE OUTCOME OF EACH HUMAN ERROR COMBINATION USING THE LOCAL MANUAL CONTROL SWITCHES IN LAUNCHER AND ASSOCIATED EQUIPMENT MOVEMENTS. FAILURE ANALYSIS REPORT ER-GS-5114 WAS PREPARED. | ANALYSIS OF COMPLETE SYSTEM FOUND NO NECESSITY FOR ADDITIONAL INTERLOCKS TO PROTECT AGAINST HUMAN ERROR. BASIC LOGIC SYSTEM IS FAIL SAFE. | X | | | SYSTEM IS FAIL SAFE AND INTERLOCKED AGAINST HUMAN ERROR. | 10 |

2.0 SYNOPSIS

ITEM: LOGIC RACKS

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: CONTRACTUAL AFBM 57-8A | DOCUMENTARY COMPLIANCE: TECH. REF. | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION: ANAL | VERIFICATION: EQUIP | VERIFICATION: TEST | RESULTS | RELATIVE VALUE % |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.4 MALFUNCTION DETECTION | PAR. 1.3.2.1 | | FAULT DETECTION SYSTEM SHOULD INCLUDE FOLLOWING CAPABILITIES:<br>1. SELF-CHECK<br>2. LAUNCHER SYSTEM CHECKOUT PRIOR TO OPERATION.<br>3. LOCALIZATION OF LAUNCHER SYSTEM MALFUNCTION TO A SINGLE COMPONENT.<br>AUTOMATION OF FAULT DETECTION IS REQUIRED TO IMPROVE PRECISION, RELIABILITY, TIME, AND RISK FACTORS. | SYSTEMS ANALYSIS USING ELECTRICAL SCHEMATICS. ALSO INSPECTION AND USE OF ACTUAL EQUIPMENT DURING SIMULATED IN-PLANT TEST PROCEDURES. | FAULT DETECTION SYSTEM CAN PERFORM SELF-CHECK. DURING LAUNCHER SYSTEM OPERATION IT CAN LOCALIZE A FAULT TO A GROUP OF COMPONENTS. IT WAS RECOMMENDED THAT THE SYSTEM SHOULD BE ABLE TO CHECK THE LAUNCHER SYSTEM BEFORE OPERATION AND BE ABLE TO LOCALIZE A FAULT TO A SINGLE FUNCTION. | X | X | X | CHECK OUT PRIOR TO LAUNCH AND DETAILED MALFUNCTION INDICATION WERE NOT ADOPTED. | 30 |
| 2.0 MAINTENANCE FACTORS<br>2.1 ACCESS, VISUAL | PAR. 4.3.3.9.1.10 | | VISUAL ACCESS SHOULD BE PROVIDED. THE PREFERRED MEANS IS AN OPENING WITH NO COVER. | DRAWING REVIEWS AND DESIGN CONFERENCES. | DOORS AND SLIDE-OUT RACKS WERE RECOMMENDED. | X | X | | ADOPTED. | 5 |
| 2.3 REMOVE AND REPLACE | PAR. 4.3.3.2<br>PAR. 4.3.3.8<br>PAR. 4.3.3.9<br>PAR. 4.3.3.3 | | REQUIREMENTS FOR ATTACHMENT OF COMPONENTS ARE DETAILED. (SEE REFERENCE).<br>REQUIREMENTS FOR MOUNTING OF COMPONENTS ARE DETAILED. (SEE REFERENCE).<br>REQUIREMENTS FOR ACCESSIBILITY OF COMPONENTS ARE DETAILED. (SEE REFERENCE).<br>HANDLES SHOULD BE PROVIDED FOR REMOVABLE CHASSIS. HANDLES SHOULD BE 4½ INCHES LONG AND 2 INCHES DEEP. | DRAWING REVIEWS AND DESIGN CONFERENCES.<br>DESIGN SPECIFICATION ADS-30148 30 NOV. 1959. | HUMAN FACTORS RECOMMENDED PLUG-IN MODULES AND WIRE HARNESS. A CODING SYSTEM WAS PROPOSED TO PREVENT INCORRECT INSERTION OF MODULES. HANDLES WERE RECOMMENDED. QUICK RELEASE FASTENERS FOR COVERS WERE RECOMMENDED, LIMITING OF PLUG AND CABLE LENGTH PREVENTS INCORRECT CONNECTOR REPLACEMENT. | X | X | | ADOPTED. | 20 |



2.0 SYNOPSIS

ITEM: LOGIC RACKS

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: CONTRACTUAL AFBM 57-8A | DOCUMENTARY COMPLIANCE: TECH. REF. | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION: ANAL. | VERIFICATION: EQUIP. | VERIFICATION: TEST | RESULTS | RELATIVE VALUE % |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.4 HANDLING, PHYSICAL LIMITATIONS | PAR. 4.3.3.1 | | MAXIMUM WEIGHTS ARE LISTED FOR REMOVABLE COMPONENTS. SEE 2.4 OF MOBILE TEST RACK SYNOPSIS. | DRAWING REVIEWS AND DESIGN CONFERENCES. | REMOVABLE COMPONENTS SHOULD MEET THE WEIGHT REQUIREMENTS SPECIFIED IN THE CRITERIA FOR SUCCESS. | | X | | ADOPTED. | 5 |
| 3.0 SAFETY FACTORS<br>3.5 SAFETY DEVICES (OTHER) | PAR. 7.0 | ASA C-33.8 1957<br>ASA C-2.4 1939 | THE SYSTEM SHALL BE PROPERLY GROUNDED. | DESIGN SPECIFICATION ABS-301A? 30 NOV. 1959 | A GROUNDED SYSTEM WAS SPECIFIED. | X | X | | ADOPTED. | 5 |
| | | | GUARD AGAINST INADVERTENT ACTUATIONS. | PERSONNEL SAFETY SPECIFICATION ABS-3005C 29 JUNE 1959 | DESIGN EQUIPMENT TO PREVENT INADVERTENT ACTUATIONS WHICH CAN RESULT IN PERSONNEL INJURY AND EQUIPMENT DAMAGE. | X | X | | ADOPTED. | 5 |
| 3.6 WARNING DEVICES | PAR. 7.2 & 7.3 | | PROVIDE WARNING DEVICES TO REDUCE THE POSSIBILITIES OF HUMAN ERROR. | DESIGN CONFERENCE AND DRAWING REVIEWS. | TRANSILLUMINATED NAMEPLATES INDICATE SAFE CONDITION FOR CONNECTION AND DISCONNECTION OF PLUGS IN CONNECTOR CHASSIS. | X | X | | ADOPTED. | 5<br>100 |

ITEM: MOBILE TEST RACK FOR OSTF

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE | | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA | | VERIFICATION | | | RESULTS | % RELATIVE VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| | CONTRACTUAL AFBM 57-8A | TECH. REF. | | PARTICIPATION | RECOMMENDATIONS | ANAL | EQUIP | TEST | | |
| 1.0 HUMAN ENGINEERING DESIGN FACTORS<br>1.1 ANTHROPOMETRIC COMPATABILITY | PAR. 6.1 | | THE MOUNTING HEIGHT OF CONTROLS AND DISPLAYS, THE HEIGHT OF THE WRITING SURFACE, AND THE SLOPE OF THE PANEL SURFACE SHOULD PERMIT OPERATION BY 90% OF THE POPULATION. | DRAWING REVIEW | IT WAS RECOMMENDED THAT THE CONTROL AND DISPLAY SURFACE SLANT AWAY FROM THE OPERATOR SO THAT THE CENTER OF THE PANEL IS PERPENDICULAR TO THE OPERATOR'S SCANNING LINE OF SIGHT (50TH PERCENTILE). | X | X | | ADOPTED. | 5 |
| 1.2 CONTROLS AND DISPLAYS | PAR. 3.1.3<br><br>PAR. 3.1.4<br><br>PAR. 3.2.1 | | 1. LOCATE AND DESIGN CONTROLS TO REDUCE PROBABILITY OF ACCIDENTAL ACTIVATION.<br>2. ARRANGE CONTROLS TO REDUCE OPERATING TIME AND ERROR PROBABILITY.<br>3. SPECIFIC REQUIREMENTS FOR PUSH BUTTONS ARE DETAILED (SEE REF.). | DRAWING REVIEW<br>BECKER & BECKER DRAWING AMP-E-3 & REPORT OF JULY 31, 1958 | RECOMMENDATIONS WERE MADE IN TO SATISFY THE CRITERIA FOR SUCCESS AS TO PROPER LOCATION OF COMPONENTS ON PANEL FRONTS. | X | X | | ADOPTED. | 5 |
| | PAR. 2.3.1.2 | | THE FOLLOWING COLOR CODING SCHEME FOR LIGHTS WILL BE ADHERED TO:<br>COLOR — MEANING<br>RED — SYSTEM INOPERATIVE, NO-GO ERROR, FAILURE MALFUNCTION<br>AMBER — SYSTEM UNSATISFACTORY, CAUTION, MARGINAL SITUATION<br>GREEN — SYSTEM IN TOLERANCE OR SATISFACTORY, GO (PERMISSION), READY NORMAL | AMF, TECHNICAL BULLETIN FOR HUMAN ENGINEERING OF PANEL FRONTS 21 APRIL 1958 | COLOR CODING REQUIREMENTS WERE SPELLED OUT AS INDICATED IN CRITERIA FOR SUCCESS. | X | X | X | ADOPTED. | 5 |



2.1 SYNOPSIS

ITEM: MOBILE TEST RACK FOR OSTF

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: CONTRACTUAL AFBM 57-8A | DOCUMENTARY COMPLIANCE: TECH. REF. | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION: ANAL. | VERIFICATION: EQUIP. | VERIFICATION: TEST | RESULTS | % RELATIVE VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| | PAR. 2.3.1.2 (CONT'D) | | COLOR: WHITE — MEANING: TRANSITORY CONDITION TEST IN PROGRESS INFORMATION | | | | | | | |
| 1.3 - FAIL SAFE DESIGN | PAR. 1.4 | | EFFORT SHOULD BE MADE TO ACHIEVE A FAIL SAFE DESIGN. | AMF DOCUMENT HR-2/3 - 5136 REVIEW OF ELECTRICAL SCHEMATICS TO DETERMINE THE OUTCOME OF EACH HUMAN ERROR COMBINATION USING THE LOCAL MANUAL CONTROL STATIONS IN LAUNCHER AND ASSOCIATED EQUIPMENT MOVEMENTS. | THE HUMAN FACTORS ANALYSIS OF TITAN LAUNCHER SYSTEM FOUND NO ADDITIONAL INTERLOCKS TO BE NECESSARY. | X | | | SYSTEM IS FAIL SAFE AND INTERLOCKED AGAINST HUMAN ERROR. | 15 |
| 2.0 MAINTENANCE FACTORS<br>2.1 ACCESS, VISUAL | PAR. 4.3.3.9.1.10 | | VISUAL ACCESS SHOULD BE PROVIDED. THE PREFERRED MEANS IS AN OPENING WITH NO COVER. | DRAWING REVIEW. | DOORS AND SLIDE-OUT RACKS WERE RECOMMENDED. | | X | | ADOPTED. | 5 |
| 2.3 REMOVE-REPLACE | PAR. 4.3.3.2<br>PAR. 4.3.3.8<br>PAR. 4.3.3.9 | | REQUIREMENTS FOR ATTACHMENT OF COMPONENTS ARE DETAILED (SEE REFERENCE).<br>REQUIREMENTS FOR MOUNTING OF COMPONENTS ARE DETAILED (SEE REFERENCE).<br>REQUIREMENTS FOR ACCESSIBILITY OF COMPONENTS ARE DETAILED (SEE REFERENCE). | DRAWING REVIEW. | RECOMMENDATIONS WERE MADE IN ACCORDANCE WITH EXHIBIT 57-8A HANDLES AND QUICK RELEASE FASTENERS FOR COVER, CORED PLUGS AND LIMITED CABLE LENGTHS WERE RECOMMENDED. | | X | | ADOPTED. | 10 |

ITEM: MOBILE TEST RACK FOR OGEP

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE | | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA | | VERIFICATION | | | RESULTS | RELATIVE VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| | CONTRACTUAL AFBM 57-8A | TECH. REF. | | PARTICIPATION | RECOMMENDATIONS | ANAL | EQUIP | TEST | | |
| 2.4 HANDLING, PHYSICAL LIMITATIONS | PAR. 4.3.3.1 | | MAXIMUM WEIGHT TO CARRY: 85 LBS. SPECIAL HANDLING EQUIPMENT MUST BE PROVIDED IF THE FOLLOWING HEIGHT-WEIGHT VALUES ARE EXCEEDED:<br>MAX. HEIGHT MAX. WEIGHT<br>1 FOOT 142 LBS.<br>2 FEET 139 LBS.<br>3 FEET 77 LBS.<br>4 FEET 55 LBS.<br>5 FEET 36 LBS.<br>6 FEET 20 LBS. | DRAWING REVIEW | REMOVABLE COMPONENTS SHOULD MEET THE WEIGHT REQUIREMENTS SPECIFIED IN THE CRITERIA FOR SUCCESS. | | | | ADOPTED | 5 |
| 2.6 VEHICLE MANEUVERABILITY | | | SIZE AND WEIGHT SHOULD BE [illegible] SO THAT THE UNIT CAN EASILY BE MOVED THROUGH DOORWAYS, CORRIDORS, TUNNELS, AND ON RAMPS AND ELEVATORS. | DRAWING REVIEW. | HUMAN FACTORS RECOMMENDED WEIGHT AND SIZE LIMITATIONS TO ENHANCE VEHICLE PORTABILITY. | X | X | | VEHICLE COULD NOT EASILY BE MOVED BETWEEN EQUIPMENT SILOS (TEST EQUIPMENT BECAME INTEGRAL PART OF LOGIC RACKS AT IF AND OB INSTALLATIONS.) | 10 |
| 3.0 SAFETY FACTORS<br>3.5 SAFETY DEVICES (OTHER) | PAR. 7.5 | | SELF-LOCKING DEVICES SHOULD BE USED TO PREVENT ACCIDENTAL OR INADVERTENT MOVEMENT. | DRAWING REVIEW. | WHEELS AND CASTORS ON THE MOBILE TEST RACK SHOULD BE OF THE LOCKING TYPE SO THAT IT CAN BE SECURED DURING OPERATION AND STORAGE. | | X | | ADOPTED | 10 |
| | | | | | | | | | | 100 |

2.1 SYNOPSIS

## 3.0 DISCUSSION

### Logic Racks

The recommendations for the design of the Logic Racks were tabulated in the preceding synopsis. The two improvements that could be made in the design of the logic system, from the human factors standpoint, are in the fault detection system and by eliminating the necessity for the operator to read the printed data from right to left.

### OSTF Mobile Test Rack

Original concepts provided for portable test equipment which would serve an entire complex to comply with austerity requirement of AFBMD. When the prototype (OSTF) model of the Mobile Test Rack was completed and designs for corridors, ramps, doorways and tunnels were established the advisability of such a concept was found questionable. Facility traffic provisions made the movement of this equipment between Equipment Silos extremely impractical.

A change in scope for TF & OB installations resulted in an improvement to this situation by providing each launcher with separate test equipment housed compactly within the Logic Racks in the Electrical Room of each Equipment Silo.

This change of scope provided an opportunity to use the Man-Machine Analysis of the Mobile Test Rack as a guide to improve human factors in the design of a new Operating Test Control Panel. This equipment was the result of close cooperative effort between human factors engineering and the electrical hardware group.

## 4.0 REFERENCES


1. AFBM Exhibit 57-8A, Human Engineering Design Standards for Missile System Equipment.

2. ASA C-2.4-1939, Safety Rules for the Operation of Electrical Equipment and Electrical Lines.

3. ASA C-33.8-1957, Grounding and Safety Equipment.

4. ADS-3014B, Design Specification-Chassis, Panels, Distribution Frames and Test Rack for WS 107A-2 Launcher System, 30 Nov. 1959.

5. ADS-1003C, Personnel Safety for WS-107A-2 Launcher System, 29 June 1959.

6. AMF Document, Technical Bulletin, #72, Human Engineering of Panel Fronts, 4/21/58.

7. C. Besserer, Missile Engineering Handbook, New York, D. Van Nostrand Company, Inc., 1958, page 378.

8. AMF Report, ER-T/S-5116, Human Factors Analysis of the Titan Launcher System, 4/5/61.

9. Becker & Becker Drawing AMF-E-3 & Report of 31 June 1958.

# Chapter 20

## Human Factors Review and Evaluation of the Tunnel Entrance & Ground Level Control Stations

LOCATION

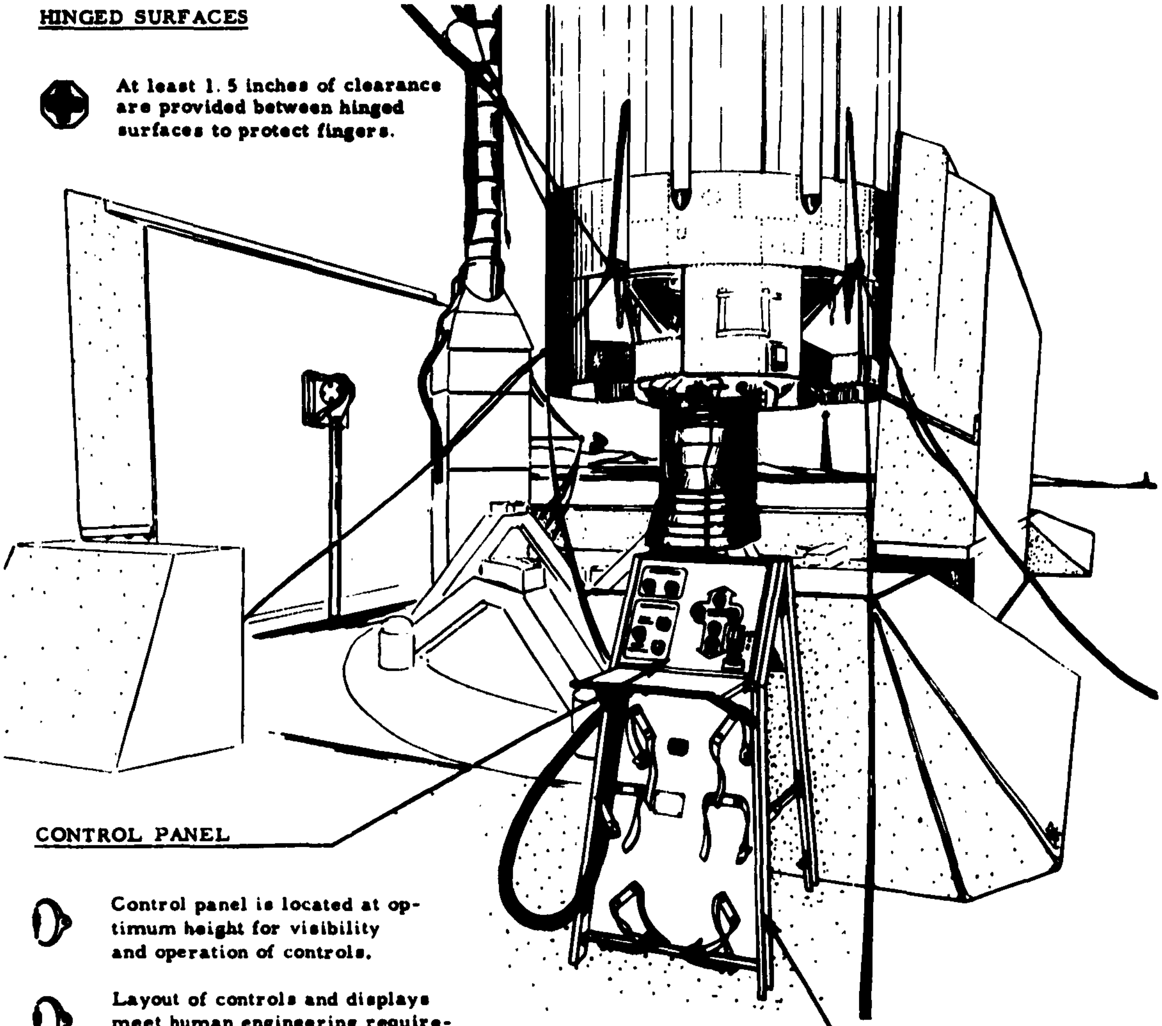
The unit is located so that missile components do not pass over the operator during missile loading.

WEATHER COVER

A weather cover is recommended for protection against the elements.

HINGED SURFACES

At least 1.5 inches of clearance are provided between hinged surfaces to protect fingers.



CONTROL PANEL

Control panel is located at optimum height for visibility and operation of controls.

Layout of controls and displays meet human engineering requirements.

Operating panel is hinged for access to the interior and the wiring.

FIXED LEGS

Fixed legs are provided for stand-up operation of the unit.

FIGURE 20-1
**HUMAN FACTORS INPUTS**
**GROUND LEVEL PORTABLE CONTROL STATION**

ILLUMINATION

Glare proof lighting is recommended.

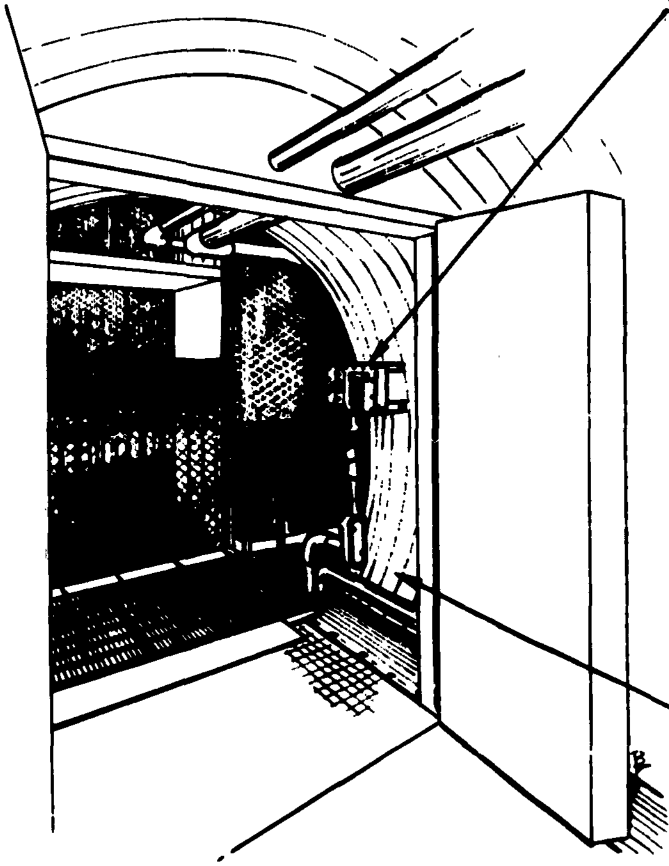
CONTROL PANEL

Control panel is mounted too low for optimum visibility and operation.

Layout of controls and displays meets human engineering requirements. All pushbuttons should be illuminated when function has been completed.

Operating panel is hinged for access to the interior and the wiring.

Panel light is provided to indicate power pack operation.



LOCATION

Unit is located where it does not interfere with tunnel to bridge traffic.

INTERLOCKS

Functions controlled by this and associated local stations are interlocked against human errors.

FIGURE 20-2
HUMAN FACTOR'S INPUTS
TUNNEL ENTRANCE CONTROL STATION

**SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO:**
GROUND LEVEL CONTROL STATION

| | | | PHASE IN STAGE | | | | HUMAN FACTORS OBJECTIVE | | | | | APPLICABLE ON MODEL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Human Factor Effort Required | Concept | Review | Analysis | Field Input | Specification Compliance | Safety | Operational Status | Maintenance Recommendation | Product Improvement | OSTF | TF | OB | SYMBOL |
| | **1.0 HUMAN ENGINEERING DESIGN FACTORS** | | | | | | | | | | | | | |  |
| 1.1 | **Anthropometric Compatability** | * | | * | | | * | | * | | | * | * | * | |
| 1.2 | **Controls and Displays** | * | | * | | | * | | * | | | * | * | * | |
| 1.3 | **Fail-Safe Design** | * | | | | | | | | | | | | | |
| 1.4 | **Malfunction Detection** | | | | | | | | | | | | | | |
| | **2.0 MAINTENANCE FACTORS** | | | | | | | | | | | | | |  |
| 2.1 | **Access, Visual** | | | | | | | | | | | | | | |
| 2.2 | **Access, Servicing** | * | | * | | | | | | * | | * | * | * | |
| 2.3 | **Remove and Replace** | | | | | | | | | | | | | | |
| 2.4 | **Handling, Physical Limitations** | * | | * | | | | | | * | | * | * | * | |
| 2.5 | **Handling, Transportation** | * | | | * | | | | | * | | * | * | * | |
| 2.6 | **Vehicle Maneuverability** | | | | | | | | | | | | | | |
| | **3.0 SAFETY FACTORS** | | | | | | | | | | | | | |  |
| 3.1 | **Chemical Decontamination** | | | | | | | | | | | | | | |
| 3.2 | **Escape Provisions** | | | | | | | | | | | | | | |
| 3.3 | **Protection from Entanglement** | | | | | | | | | | | | | | |
| 3.4 | **Protection from Falling** | | | | | | | | | | | | | | |
| 3.5 | **Safety Devices (other)** | * | | * | | | | * | | | | * | * | * | |
| 3.6 | **Warning Devices** | | | | | | | | | | | | | | |
| | **4.0 PHYSIOLOGICAL FACTORS** | | | | | | | | | | | | | |  |
| 4.1 | **Biological Damage** | | | | | | | | | | | | | | |
| 4.2 | **Vertigo** | | | | | | | | | | | | | | |
| 4.3 | **Vibration Effects** | | | | | | | | | | | | | | |
| | **5.0 PSYCHOLOGICAL FACTORS** | | | | | | | | | | | | | |  |
| 5.1 | **Fear of Heights** | | | | | | | | | | | | | | |
| 5.2 | **Fear of Being Crushed** | | | | | | | | | | | | | | |
| 5.3 | **Fear of Falling** | * | | * | | | | * | | | | * | * | * | |
| 5.4 | **Fear of Isolation** | | | | | | | | | | | | | | |
| 5.5 | **Feeling of Insecurity** | * | | * | | | | * | | | | * | * | * | |
| | **6.0 ENVIRONMENTAL FACTORS** | | | | | | | | | | | | | |  |
| 6.1 | **Acoustic Energy (noise)** | | | | | | | | | | | | | | |
| 6.2 | **Humidity & Temperature** | * | | * | | | | | * | | | * | * | * | |
| 6.3 | **Illumination** | * | | * | | | * | | * | | | * | * | * | |
| | **7.0 HUMAN USE FACTORS** | | | | | | | | | | | | | |  |
| 7.1 | **Procedure** | | | | | | | | | | | | | | |
| 7.2 | **Time Study** | | | | | | | | | | | | | | |
| 7.3 | **Training/Selection** | | | | | | | | | | | | | | |

FIGURE 20-3

**SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO:**
TUNNEL ENTRANCE CONTROL STATION

| | | | PHASE IN STAGE | | | | HUMAN FACTORS OBJECTIVE | | | | | APPLICABLE ON MODEL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Human Factor Effort Required | Concept | Review | Analysis | Field Input | Specification Complicance | Safety | Operational Status | Maintenance Recommendation | Product Improvement | OSTF | TF | OB | SYMBOL |
| | **1.0 HUMAN ENGINEERING DESIGN FACTORS** | | | | | | | | | | | | | | |
| **1.1** | **Anthropometric Compatability** | * | | * | | | * | | * | | | * | * | * |  |
| **1.2** | **Controls and Displays** | * | | * | | | * | | * | | | * | * | * | |
| **1.3** | **Fail-Safe Design** | * | | | * | | | * | | | | * | * | * | |
| **1.4** | **Malfunction Detection** | | | | | | | | | | | | | | |
| | **2.0 MAINTENANCE FACTORS** | | | | | | | | | | | | | | |
| **2.1** | **Access, Visual** | | | | | | | | | | | | | |  |
| **2.2** | **Access, Servicing** | * | | * | | | | | | * | | * | * | * | |
| **2.3** | **Remove and Replace** | | | | | | | | | | | | | | |
| **2.4** | **Handling, Physical Limitations** | | | | | | | | | | | | | | |
| **2.5** | **Handling, Transportation** | | | | | | | | | | | | | | |
| **2.6** | **Vehicle Maneuverability** | * | | * | | | * | * | | | | * | * | * | |
| | **3.0 SAFETY FACTORS** | | | | | | | | | | | | | | |
| **3.1** | **Chemical Decontamination** | | | | | | | | | | | | | |  |
| **3.2** | **Escape Provisions** | | | | | | | | | | | | | | |
| **3.3** | **Protection from Entanglement** | | | | | | | | | | | | | | |
| **3.4** | **Protection from Falling** | | | | | | | | | | | | | | |
| **3.5** | **Safety Devices (other)** | * | | * | | | | | | | | * | * | * | |
| **3.6** | **Warning Devices** | | | | | | | | | | | | | | |
| | **4.0 PHYSIOLOGICAL FACTORS** | | | | | | | | | | | | | | |
| **4.1** | **Biological Damage** | | | | | | | | | | | | | |  |
| **4.2** | **Vertigo** | | | | | | | | | | | | | | |
| **4.3** | **Vibration Effects** | | | | | | | | | | | | | | |
| | **5.0 PSYCHOLOGICAL FACTORS** | | | | | | | | | | | | | | |
| **5.1** | **Fear of Heights** | | | | | | | | | | | | | |  |
| **5.2** | **Fear of Being Crushed** | | | | | | | | | | | | | | |
| **5.3** | **Fear of Falling** | * | | * | | | | * | | | | * | * | * | |
| **5.4** | **Fear of Isolation** | | | | | | | | | | | | | | |
| **5.5** | **Feeling of Insecurity** | | | | | | | | | | | | | | |
| | **6.0 ENVIRONMENTAL FACTORS** | | | | | | | | | | | | | | |
| **6.1** | **Acoustic Energy (noise)** | | | | | | | | | | | | | |  |
| **6.2** | **Humidity & Temperature** | | | | | | | | | | | | | | |
| **6.3** | **Illumination** | * | | * | | | * | | * | | | * | * | * | |
| | 7.0 HUMAN USE FACTORS | | | | | | | | | | | | | | |
| 7.1 | Procedure | | | | | | | | | | | | | |  |
| 7.2 | Time Study | | | | | | | | | | | | | | |
| 7.3 | Training/Selection | | | | | | | | | | | | | | |

FIGURE 20-4

## 1.0 DESCRIPTION

In this chapter the human factors will be considered which are pertinent to the design and installation of the Ground Level Portable Control Station and the Tunnel Entrance Control Station.

## 1.1 Ground Level Portable Control Station

### 1.1.1 Description

The Ground Level Portable Control Station is used during the stage handling task to operate the launcher platform and may also be used to test the water spray system during periodic maintenance checks. This station is portable with a fifty foot cable extension and is mounted on fixed legs for stand-up operation. The connection of this station into the system disables the Tunnel Entrance Control Station. The Ground Level Portable Control Station is not operable unless the following conditions are satisfied:

a) It is plugged into the connection box,

b) The Cycling Control Station master switch is not in the local position,

c) The system safety interlocks permit equipment actuation, and

d) The circuit breakers in the Motor Control Station are closed.

### 1.1.2 Applicable Human Factor Considerations

The Ground Level Portable Control Station must be designed for operation by Air Force personnel between the 5th and 95th percentile. The unit must be transportable and access must be provided to components and wiring. The station should be located so that the operator is not too close to the silo opening and missile components do not pass over his head during loading. Consideration should be

given to the use of the unit at night and during inclement weather. Controls and displays must be located so as to reduce the probability of operator error.

1.2 Tunnel Entrance Control Station

1.2.1 Description

The Tunnel Entrance Control Station is used for local control of the Launcher Platform before and after stage handling and for periodic maintenance checks. This station is located at the entrance of the personnel tunnel into the silo.

The Tunnel Entrance Control Station is not operable unless the following conditions are satisfied:

a. the Ground Level Portable Control Station is not connected,
b. the Cycling Control Station master switch is not in the local position,
c. the system safety interlocks permit equipment operation, and
d. the circuit breakers in the Motor Control Station are closed.

1.2.2 Applicable Human Factor Considerations

The Tunnel Entrance Control Station must be designed for operation by Air Force personnel between the 5th and 95th percentile. Controls and displays must be located so as to reduce the probability of operator error. Access must be provided to components and wiring. The station must be designed and located so that it does not interfere with the passage of vehicles through the tunnel and across the Crib-to-Silo Bridge. Consideration should be given to lighting and fail safe design.

ITEM: GROUND LEVEL PORTABLE CONTROL STATION

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE | | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA | | VERIFICATION | | | RESULTS | RELATIVE VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| | CONTRACTUAL AFBM 57-5A | TECH. REF. | | PARTICIPATION | RECOMMENDATIONS | ANAL. | EQUIP. | TEST | | % |
| 1.0 HUMAN ENGINEERING DESIGN FACTORS<br>1.1 ANTHROPOMETRIC COMPATABILITY | PAR. 6.1 | | THE MOUNTING HEIGHT OF CONTROLS AND DISPLAYS, THE HEIGHT OF THE WRITING SURFACE, AND THE SLOPE OF THE PANEL SURFACE SHOULD PERMIT OPERATION BY 90% OF THE POPULATION. | DRAWING REVIEW ER-GPC-173 2-11-59. | 1. THE WRITING SURFACE SHOULD BE ADJUSTABLE WITHIN 15° TO 30° BELOW A LINE PARALLEL TO THE GROUND.<br>2. THE PANEL ANGLE SHOULD BE 90° ± 10° TO THE LINE OF SIGHT. (AT PANEL CENTER)<br>3. THE PANEL SURFACE SHOULD BE 26" FROM THE EYE POSITION OF THE 50TH PERCENTILE (64.7") ON A LINE 15° DOWN FROM THE NORMAL LINE OF SIGHT. | | X | | ADOPTED. | 10 |
| 1.2 CONTROLS AND DISPLAYS | PAR. 3.1.3<br>PAR. 3.1.4<br>PAR. 3.2.1 | | LOCATE AND DESIGN CONTROLS TO REDUCE PROBABILITY OF ACCIDENTAL ACTIVATION.<br>ARRANGE CONTROLS TO REDUCE OPERATING TIME AND ERROR PROBABILITY.<br>PUSHBUTTONS SHOULD BE DESIGNED WITH<br>A. MINIMUM DIAMETER OF ½"<br>B. DISPLACEMENT OF 1/8 TO 1½"<br>C. RESISTANCE OF 10 TO 40 OUNCES, AND<br>D. AUDIBLE CLICK TO INDICATE ACTIVATION. | DRAWING REVIEW ER-GPC-80 8/6/58.<br>EF-P-1160<br>EF-P-1161 | RECOMMENDATIONS ON CONTROL LAYOUT WERE MADE. | | X | X | ADOPTED WITH EXCEPTION OF PUSHBUTTONS WHICH ARE NEITHER LIGHTED NOR INCLUDE AN AUDIBLE CLICK TO INDICATE ACTIVATION. | 10 |

2.0 SYNOPSIS

ITEM: GROUND LEVEL PORTABLE CONTROL STATION

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE | | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA | | VERIFICATION | | | RESULTS | RELATIVE VALUE % |
|---|---|---|---|---|---|---|---|---|---|---|
| | CONTRACTUAL AFBM 57-8A | TECH. REF. | | PARTICIPATION | RECOMMENDATIONS | ANAL. | EQUIP. | TEST | | |
| 2.0 MAINTENANCE FACTORS<br>2.2 ACCESS, SERVICING | PAR. 4.3.3.7 | | HINGED PA[illegible] [illegible]R ACCESS SHOULD BE PROVIDED. | DRAWING REVIEW ER-TPS-156 12-10-58 | A HINGED OPERATING PANEL FOR ACCESS TO THE INTERIOR AND WIRING. | | X | | ADOPTED. | 10 |
| 2.4 HANDLING, PHYSICAL LIMITATIONS | PAR. 4.3.3.3 | | SPECIAL HANDLING EQUIPMENT SHALL BE PROVIDED FOR GRASPING AND HANDLING. | DRAWING REVIEW ER-TPS-158 12-10-58 | HANDLES FOR LIFTING AND CARRYING WERE RECOMMENDED. | | X | | ADOPTED. | 10 |
| 2.5 HANDLING, TRANSPORTATION | PAR. 4.3.3 | | SPECIAL HANDLING EQUIPMENT SHOULD BE PROVIDED FOR UNITS TOO HEAVY TO BE CARRIED BY ONE MAN. | DESIGN CONFERENCE TO IMPLEMENT FIELD REQUEST. | FIELD REQUESTED WHEELS TO IMPROVE PORTABILITY. | | X | | ADOPTED. | 10 |
| 3.0 SAFETY FACTORS<br>3.5 SAFETY DEVICES | PAR. 7.0 | | PROVIDE CLEARANCE FOR FINGERS BETWEEN HINGED SURFACES. | DRAWING REVIEW ER-TPS-173 2-11-59 | A CLEARANCE OF 15° BETWEEN HINGED SURFACES WAS RECOMMENDED. | | X | | ADOPTED. | 10 |
| | PAR. 3.1.3 | | INTERLOCK THE SYSTEM AGAINST INADVERTENT OPERATION BY PERSONS AT ONE STATION WHILE OPERATIONS ARE BEING INITIATED AT ANOTHER STATION. | DESIGN CONCEPT MEETING. REVIEWED AS PART OF <u>HUMAN FACTORS ANALYSIS OF THE TITAN LAUNCHER SYSTEM</u>. | HUMAN FACTORS ENGINEERING REQUESTED INTERLOCKS WHICH WOULD MAKE THE TUNNEL ENTRANCE CONTROL STATION COMPLETELY INOPERATIVE WHILE THE GROUND LEVEL PORTABLE CONTROL STATION WAS CONNECTED.<br>WHILE IT IS OPEN, THE G.L.P.C.S CONNECTION BOX COVER ACTUATES LIMIT SWITCHES WHICH OPEN CIRCUITRY FROM THE TECS TO LOGIC. | X | X | | INTERLOCKS HAVE BEEN PROVIDED. | 10 |
| 5.0 PSYCHOLOGICAL FACTORS<br>5.3 FEAR OF FALLING | PAR. 7.8 | | PROTECTION AGAINST FALLING SHOULD BE PROVIDED AROUND OPENINGS. | SYSTEMS ANALYSIS. | THE OPERATOR SHOULD BE LOCATED FAR ENOUGH FROM THE SILO OPENING SO THAT HE EXPERIENCES NO FEAR OF FALLING. | | | X | OPERATOR IS LOCATED 15' FROM THE SILO OPENING. | 5 |

2.0 SYNOPSIS

ITEM: GROUND LEVEL PORTABLE CONTROL STATION

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE | | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA | | VERIFICATION | | | RESULTS | % RELATIVE VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| | CONTRACTUAL AFBM 57-8A | TECH. REF. | | PARTICIPATION | RECOMMENDATIONS | ANAL | EQUIP | TEST | | |
| 5.5 FEELING OF INSECURITY | PAR. 7.0 | | PRECAUTION SHOULD BE TAKEN TO PROTECT THE OPERATOR AND EQUIPMENT DURING SYSTEM OPERATION | SYSTEMS ANALYSIS. | STATION SHOULD BE LOCATED SO THAT THE CRANE ARM DOES NOT PASS OVER THE OPERATOR'S HEAD. | | | X | ADOPTED. | 10 |
| 6.0 ENVIRONMENTAL FACTORS<br>6.2 HUMIDITY AND TEMPERATURE | | | OPERATOR SHOULD BE PROTECTED AGAINST EFFECTS OF SUN, RAIN, AND SNOW. | DRAWING REVIEW. | A WEATHER COVER SHOULD BE PROVIDED FOR PROTECTION AGAINST THE ELEMENTS. | | X | | NOT ADOPTED. | 5 |
| 6.3 ILLUMINATION | PAR. 7.21 | | WORK AREAS SHOULD BE ILLUMINATED BY AT LEAST 25 FOOT CANDLES. | SYSTEMS ANALYSIS. | PROVIDE ADDITIONAL ILLUMINATION FOR OPERATION OF THE STATION AT NIGHT AND ON OVERCAST DAYS. | | X | | NOT ADOPTED. | 10 |
| | | | | | | | | | | 100 |

ITEM: TUNNEL ENTRANCE CONTROL STATION

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: CONTRACTUAL AFBM 57-8A | DOCUMENTARY COMPLIANCE: TECH. REF. | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION: ANAL | VERIFICATION: EQUIP | VERIFICATION: TEST | RESULTS | RELATIVE VALUE % |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 HUMAN ENGINEERING DESIGN FACTORS | | | | | | | | | | |
| 1.1 ANTHROPOMETRIC COMPATABILITY | | MISSILE ENGINEERING HANDBOOK | CONTROL PANEL SHOULD BE BETWEEN 60.3" AND 69.1" ABOVE THE GROUND TO INCLUDE 95 % OF THE POPULATION. | HF-T-1047 TUNNEL ENTRANCE CONTROL STATION STUDY INDICATED CORRECT PANEL HEIGHT. | CONTROL PANEL LOCATION IN ACCORDANCE WITH REFERENCE WAS RECOMMENDED. | X | X | | NOT ADOPTED. CENTER OF CONTROL PANEL IS 52" ABOVE THE FLOORING. | 10 |
| 1.2 CONTROLS AND DISPLAYS | PAR. 3.1.3<br>PAR. 3.1.4<br>PAR. 3.2.1 | | 1. LOCATE AND DESIGN CONTROLS TO REDUCE PROBABILITY OF ACCIDENTAL ACTIVATION.<br>2. ARRANGE CONTROLS TO REDUCE OPERATING TIME AND ERROR PROBABILITY.<br>3. PUSHBUTTONS SHOULD BE DESIGNED WITH<br>A. MINIMUM DIAMETER OF ½"<br>B. DISPLACEMENT OF 1/8 TO 1½"<br>C. RESISTANCE OF 10 TO 40 OUNCES, AND<br>D. AUDIBLE CLICK TO INDICATE ACTIVATION. | HF-T-1094 REVISED T.E.C.S. PANEL LAYOUT.<br>ER-TPB-82 8-11-58<br>ADTP-T-2056 ADDENDUM A 27 FEB. 1960 HUMAN FACTORS TEST PROCEDURE TUNNEL ENTRANCE CONTROL STATION | CRITERIA FOR PUSHBUTTONS WAS TRANSMITTED AND DESIGN ASSISTANCE WAS PROVIDED IN THE LAYOUT OF CONTROL PANEL. PANEL SIZE WAS REDUCED. | X | X | X | ADOPTED WITH EXCEPTION OF PUSHBUTTONS WHICH ARE NEITHER LIGHTED NOR INCLUDE AN AUDIBLE CLICK TO INDICATE ACTIVATION. CONTROL ARRANGEMENTS PROVED CORRECT IN SEQUENCE TEST ADTP-T 2056. | 10 |
| 1.3 FAIL SAFE DESIGN | PAR. 1.4 | | EFFORT SHOULD BE MADE TO ACHIEVE A FAIL SAFE DESIGN. | REVIEW OF ELECTRICAL SCHEMATICS. ER T/S-5116 | HUMAN FACTORS ANALYSIS OF TITAN LAUNCHER SYSTEM FOUND NO ADDITIONAL INTERLOCKS TO BE NECESSARY. | X | | | SYSTEM IS FAIL SAFE | 10 |

2.1 SYNOPSIS

ITEM: TUNNEL ENTRANCE CONTROL STATION

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE | | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA | | VERIFICATION | | | RESULTS | RELATIVE VALUE % |
|---|---|---|---|---|---|---|---|---|---|---|
| | CONTRACTUAL AFBM 57-8A | TECH. REF. | | PARTICIPATION | RECOMMENDATIONS | ANAL | EQUIP | TEST | | |
| 2.0 MAINTENANCE FACTORS<br>2.2 ACCESS, SERVICING | PAR. 4.3.3.9 | | HINGED PANELS FOR ACCESS SHOULD BE PROVIDED. | DESIGN CONFERENCE AND DRAWING REVIEWS. | A HINGED OPERATING PANEL FOR ACCESS TO THE INTERIOR AND WIRING WAS RECOMMENDED. | | X | | ADOPTED. | 15 |
| 2.6 VEHICLE MANEUVERABILITY | | | THE STATION SHOULD BE DESIGNED AND LOCATED SO THAT IT DOES NOT INTERFERE WITH THE PASSAGE OF VEHICLES THROUGH THE TUNNEL AND ACROSS THE CRIB-TO-SILO BRIDGE. | SP-T-1047 TUNNEL ENTRANCE CONTROL STATION STUDY INDICATED LOCATIONS SUGGESTED BY HUMAN FACTORS ENGINEERING. | A MODIFICATION IN THE LOCATION OF THE TUNNEL ENTRANCE CONTROL STATION WAS RECOMMENDED TO PERMIT VEHICLE PASSAGE. | | | X | ADOPTED. | 20 |
| 3.0 SAFETY FACTORS<br>3.5 SAFETY DEVICES | PAR. 7.2 | | WARNING DEVICES SHOULD BE PROVIDED FOR THE POSITION OF CRITICAL CONTROLS. | DESIGN CONFERENCE AND DRAWING REVIEW. | LIGHTS WERE RECOMMENDED TO INDICATE POWER PACK OPERATION. | X | X | | ADOPTED. | 10 |
| | PAR. 3.1.3 | | INTERLOCK THE SYSTEM AGAINST INADVERTENT OPERATION BY PERSONS AT ONE STATION WHILE OPERATIONS ARE BEING INITIATED AT ANOTHER STATION. | DESIGN CONCEPT MEETING. REVIEWED AS PART OF <u>HUMAN FACTORS ANALYSIS OF THE TITAN LAUNCHER SYSTEM</u>. ER-T/S-5116. | HUMAN FACTORS ENGINEERING SUGGESTED INTERLOCKS WHICH WOULD MAKE THE TUNNEL ENTRANCE CONTROL STATION COMPLETELY INOPERATIVE WHILE THE GROUND LEVEL PORTABLE CONTROL STATION WAS CONNECTED. WHILE IT IS OPEN, THE G.L.P.C.S. CONNECTION BOX COVER ACTUATES LIMIT SWITCHES WHICH OPEN CONTROL CIRCUITRY FROM THE T.E.C.S. TO LOGIC. | X | X | | INTERLOCKS HAVE BEEN PROVIDED. | 10 |

ITEM: TUNNEL ENTRANCE CONTROL STATION

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: CONTRACTUAL AFBM 57-8A | DOCUMENTARY COMPLIANCE: TECH. REF. | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION: ANAL | VERIFICATION: EQUIP | VERIFICATION: TEST | RESULTS | % RELATIVE VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| 5.0 PSYCHOLOGICAL FACTORS<br>5.3 FEAR OF FALLING | PAR. 7.8,7.9<br><br>PAR. 7.22 | | PROVIDE HANDRAILS OR SAFETY CHAINS AT OPENINGS.<br>PROVIDE SKID PROOF FLOORING. | DRAWING REVIEW.<br>ER-TPS-146. | IT WAS ANTICIPATED THAT FEAR OF FALLING WOULD BE A PROBLEM FOR THE OPERATOR OF THIS STATION. SAFETY CHAINS, HAND RAIL EXTENSIONS, OPAQUE CURTAINS, AND SKID PROOF FLOORING RECOMMENDED. | X | X | | THE TUNNEL ENTRANCE CONTROL STATION IS LOCATED SO THAT FEAR OF FALLING IS NOT A PROBLEM DUE TO THE PLACEMENT OF UTILITIES AND OTHER ASSOCIATED CONTRACTOR EQUIPMENT IN THE AREA. | 5 |
| 6.0 ENVIRONMENTAL FACTORS<br>6.3 ILLUMINATION | PAR. 7.21 | | NOSE AREAS SHOULD BE ILLUMINATED BY AT LEAST 25 FOOT CANDLES. | REVIEW OF IN.BN DRAWINGS. | SILO LIGHTING WAS FOUND TO BE INADEQUATE. | X | | | AMF TRANSMITTED A LETTER ON 6/24/59 TO BMD-GEL SIGNED BY A. J. [illegible] ON THE SUBJECT "LIGHTING SYSTEM IN MISSILE SILO". | 10 |
| | | | | | | | | | | 100 |

## 3.0 DISCUSSION

Construction of the silo cap, electrical requirements, reliability and safety considerations (50 foot cable length) all dictated the design of the Ground Level Portable Control Station. In order to provide a more compact, more portable unit all of these factors would have to be modified in basic concept.

Early concepts indicated that the Tunnel Entrance Control Station would be located near the Crib-to-Silo bridge and the operator would have a panoramic view of the Silo. For these reasons it was anticipated that fear of falling and a general sense of insecurity might represent problems for the operator. However, in the present system, equipment has been modified and added so that the operator should not experience either a fear of falling or a feeling of insecurity. This problem is referenced in the synopsis since it did represent effort on the program.

## 4.0 REFERENCES


1. AFBM Exhibit 57-8A, Human Engineering Design Standards for Missile System Equipment.

2. ADTP-V-2056, Addendum A, Human Factors Test Procedure Tunnel Entrance Control Station.

3. Daniel, Mann, Johnson & Mandenhall and Associates, WS 107A-2, Technical Facilities Mountain Home Air Force Base, Mt. Home, Idaho, Volume I, Sheet #92-E-1; Volume II, Sheets #93-E-1,2.

4. C. Besserer, Missile Engineering Handbook, New York, D. Van Nostrand Company, Inc., 1958, page 378.

5. AMF Report, ER-T/S-5116, Human Factors Analysis of the Titan Launcher System, 4/5/61.

6. AMF Report, ER-TPS-88, Ground Level Control Station Human Engineering Report, 8/6/58.

7. AMF Report, ER-TPS-156, Ground Level Portable Control Station Design Considerations, 12/10/58.

8. AMF Report,ER-TPS-82, Tunnel Entrance Control Station Electrical System, 8/11/58.

9. AMF Report, ER-TPS-146, Tunnel Entrance Control Station, 11/26/58.

10. AMF Drawing HF-T-1160, Ground Level Control Station Layout.

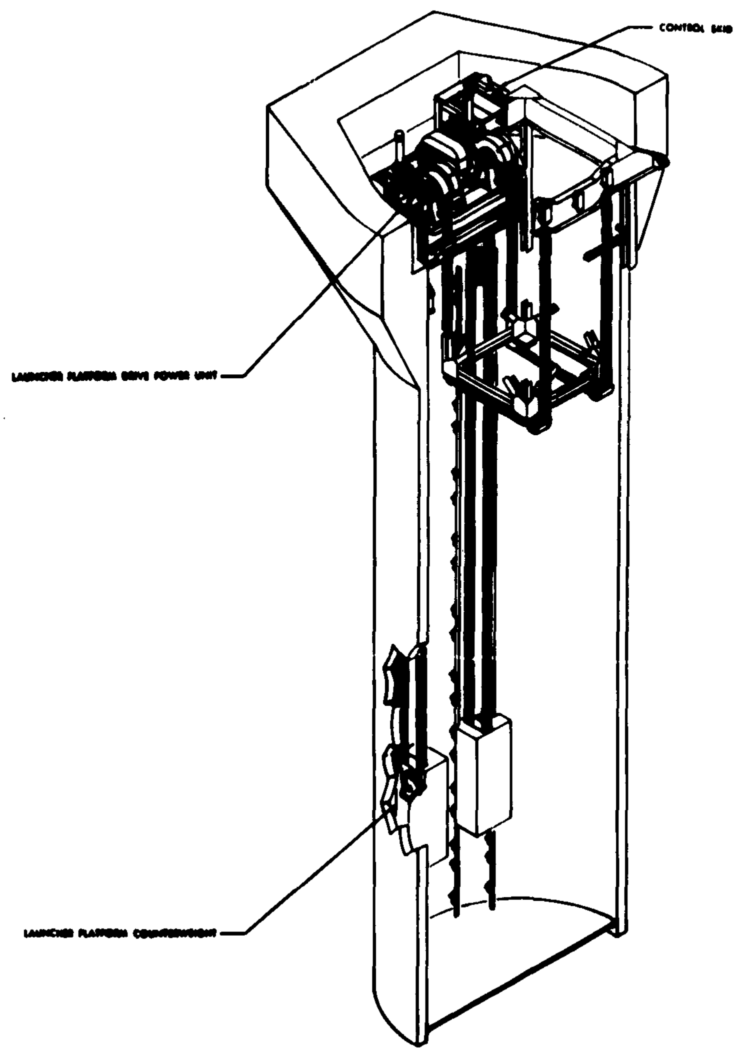
11. AMF Drawing HF-T-1161, Control Station Analysis - Motion Study.

12. AMF Drawing HF-T-1047, Tunnel Entrance Control Station Study.

13. AMF Document, TS 7.2.20, Lighting System in Missile Silo, 6/24/59.

# Chapter 21

## Human Factors Review and Evaluation of the Main Drive System




**COVER GUARD**

A cover guard should be provided for the Main Drive Brake to prevent injury from entanglement.

**ACCESS**

A ladder should be added from platform 1 to provide access to the drive base. A ramp should be provided over the drive base to the catwalk.

**AUXILIARY DRIVE**

A jacking motor should be installed as an auxiliary means of activating the Launcher Platform in the event of Main Drive failure.

**ACCESS PLATFORM**

A platform has been provided for servicing the counterweight support mechanism.

FIGURE 21-1
HUMAN FACTORS INPUTS
MAIN DRIVE

**SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO:**

MAIN DRIVE

| No. | Factor | Human Factor Effort Required | Concept (Phase II Stage) | Review (Phase II Stage) | Analysis (Phase II Stage) | Field Input (Phase II Stage) | Specification Compliance (Human Factors Objective) | Safety (Human Factors Objective) | Operational Status (Human Factors Objective) | Maintenance Recommendation (Human Factors Objective) | Product Improvement (Human Factors Objective) | OSTF (Applicable on Model) | TF (Applicable on Model) | OB (Applicable on Model) | Symbol |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | **HUMAN ENGINEERING DESIGN FACTORS** | | | | | | | | | | | | | | |
| 1.1 | Anthropometric Compatability | | | | | | | | | | | | | | |
| 1.2 | Controls and Displays | | | | | | | | | | | | | | |
| 1.3 | Fail-Safe Design | | | | | | | | | | | | | | |
| 1.4 | Malfunction Detection | | | | | | | | | | | | | | |
| 2.0 | **MAINTENANCE FACTORS** | | | | | | | | | | | | | | |
| 2.1 | Access, Visual | | | | | | | | | | | | | | |
| 2.2 | Access, Servicing | * | | * | | | | | | * | | * | * | * | |
| 2.3 | Remove and Replace | * | | * | | | | | | * | | * | * | * | |
| 2.4 | Handling, Physical Limitations | | | | | | | | | | | | | | |
| 2.5 | Handling, Transportation | * | | * | | | | | | * | | * | * | * | |
| 2.6 | Vehicle Maneuverability | | | | | | | | | | | | | | |
| 3.0 | **SAFETY FACTORS** | | | | | | | | | | | | | | |
| 3.1 | Chemical Decontamination | | | | | | | | | | | | | | |
| 3.2 | Escape Provisions | | | | | | | | | | | | | | |
| 3.3 | Protection from Entanglement | * | | * | | | | * | | | | * | * | * | |
| 3.4 | Protection from Falling | * | | * | | | | * | | * | | * | * | * | |
| 3.5 | Safety Devices (other) | * | | * | | | | * | | * | | * | * | * | |
| 3.6 | Warning Devices | * | | * | | | | * | | | | * | * | * | |
| 4.0 | **PHYSIOLOGICAL FACTORS** | | | | | | | | | | | | | | |
| 4.1 | Biological Damage | | | | | | | | | | | | | | |
| 4.2 | Vertigo | | | | | | | | | | | | | | |
| 4.3 | Vibration Effects | | | | | | | | | | | | | | |
| 5.0 | **PSYCHOLOGICAL FACTORS** | | | | | | | | | | | | | | |
| 5.1 | Fear of Heights | | | | | | | | | | | | | | |
| 5.2 | Fear of Being Crushed | | | | | | | | | | | | | | |
| 5.3 | Fear of Falling | | | | | | | | | | | | | | |
| 5.4 | Fear of Isolation | | | | | | | | | | | | | | |
| 5.5 | Feeling of Insecurity | | | | | | | | | | | | | | |
| 6.0 | **ENVIRONMENTAL FACTORS** | | | | | | | | | | | | | | |
| 6.1 | Acoustic Energy (noise) | | | | | | | | | | | | | | |
| 6.2 | Humidity & Temperature | | | | | | | | | | | | | | |
| 6.3 | Illumination | | | | | | | | | | | | | | |
| 7.0 | **HUMAN USE FACTORS** | | | | | | | | | | | | | | |
| 7.1 | Procedure | | | | | | | | | | | | | | |
| 7.2 | Time Study | | | | | | | | | | | | | | |
| 7.3 | Training/Selection | | | | | | | | | | | | | | |

FIGURE 21-2

## 1.0 DESCRIPTION

1.1 In this chapter the human factors will be considered which are pertinent to the design and installation of the Main Drive. The Main Drive system includes the launcher platform drive system and the power transmission unit which work together to raise or lower the missile. The launcher platform drive system is a complete system of counterweights, cables, and support mechanisms that control the vertical movement of the platform and missile at any desired level in the silo. The drive power unit is a separate hydraulically operated motor and gear reducer. Cables of the drive system are fed through the drive sheaves which are geared to the hydraulic motor.

The system of cables and counterweights for the launcher platform drive system consists of two separate sets of elevator cables attached at one end to the top of the crib structure and strung under the launcher platform through idler pulleys, up into the drive sheaves, down again through two sets of counterweight sheaves, and back up into the tension equalizer cylinders which maintain equal tension on the cables as a stability measure to level the platform. The counterweights slide up and down along guide rails mounted to the silo wall.

When the launcher platform is at the base of the missile silo the weight of the leaded counterweights is supported by two support mechanisms attached to the silo wall. When the launcher platform is moved from the base of the silo, the counterweight support mechanisms are stowed so as to bring the full weight of the counterweights on the system.

A counterweight lifting and locking assembly lifts the counterweight while the launcher system is in the hard state, and it imparts slack to launcher

cables during shock conditions in order to maintain a relative motion between the crib and the silo wall.

The launcher platform drive power unit supplies the power to raise the launcher platform and missile to launch attitude or any intermediate position for maintenance purposes. The power unit is located on the silo wall. The motor is a hydraulic pump-type motor that converts hydraulic pressure into rotary mechanical power. The motor incorporates a release brake for stopping or holding the platform at any desired position in the silo. The braking unit can also stop the launcher platform under conditions of hydraulic or mechanical failure. A speed reducer provides low speed, high torque power.

1.2 Men of the Air Force population who represent body sizes between the 5th and 95th percentile must be able to perform maintenance on the Main Drive components efficiently and safely. Adequate access must be provided to all equipment. Special handling equipment must be available for all components that cannot be readily removed and replaced by a single operator. The equipment must be designed so that the hazards of falling, entanglement, etc. are minimized.

ITEM: [illegible]

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: [illegible] | DOCUMENTARY COMPLIANCE: TECH REF | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION: ANAL | VERIFICATION: [illegible] | VERIFICATION: TEST | RESULTS | [illegible] |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.0 MAINTENANCE FACTORS | | | | | | | | | | |
| 2.2 ACCESS, SERVICING | PAR. 4.21 AND 6.1.1 | | [illegible] IS ONE OF THE GENERAL PRINCIPLES OF EQUIPMENT DESIGN FOR MAINTAINABILITY. [illegible] REQUIRES THAT EQUIPMENT BE DESIGNED TO PROVIDE FOR RAPID AND EASY REMOVAL AND REPLACEMENT OF UNITS BY A SINGLE OPERATOR, IF POSSIBLE. PARAGRAPH 6.1.1 LISTS [illegible] WHICH MUST BE CONSIDERED TO MAKE EQUIPMENT ACCESSIBLE FOR MAINTENANCE PERSONNEL. | TM 7.2.23 | TWO 4½ FOOT AND ONE 4 FOOT LADDER SHOULD BE PROVIDED FOR [illegible] ACCESS TO THE CLOSURE DOOR SEALS. | X | | | THIS IS A MAINTENANCE ITEM WHICH HAS NOT BEEN [illegible] AS YET. SEE SECTION 2.3 | 4 |
| | | | | [illegible]-070-280 | A LADDER SHOULD BE ADDED FROM WORK PLATFORM 1 PROVIDING ACCESS TO THE [illegible] DOOR. | X | | | SEE 2.2 ABOVE. | [illegible] |
| | | | | [illegible]-070-215, [illegible]-070-280, AND [illegible]-0-2065. A STANDARD ELECTRIC MOTOR AND [illegible] WERE SELECTED FOR INSTALLATION AS AN AUXILIARY MEANS OF ACTUATING THE LAUNCHER PLATFORM. | A JACKING MOTOR SHOULD BE INSTALLED AS AN AUXILIARY MEANS OF ACTUATING THE LAUNCHER PLATFORM. THIS MOTOR COULD BE USED TO ACTUATE THE LAUNCHER PLATFORM PRIOR TO THE CONNECTION OF THE HYDRAULIC SYSTEM DURING INSTALLATION AND ALSO IN THE EVENT OF A HYDRAULIC FAILURE. ACCESSIBILITY TO THE [illegible] MOTOR AND REPLACEMENT OF THIS UNIT WOULD BE EXTREMELY DIFFICULT IF FAILURE OCCURRED WHEN THE PLATFORM IS IN THE [illegible] POSITION. | X | | | NOT ADOPTED. | 26 |
| | | | | | [illegible] THE ADDITION OF AN ACCESS PLATFORM FOR THE [illegible] SUPPORT [illegible] | | | | ADOPTED | [illegible] |

ITEM: MAIN DRIVE

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: CONTRACTUAL [illegible] | DOCUMENTARY COMPLIANCE: TECH REF | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION: [illegible] | VERIFICATION: [illegible] | VERIFICATION: [illegible] | RESULTS | [illegible] |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.3 [illegible]-REPLACE | PAR. 4.3.3.4 | | [illegible] AND STANDS ON WHICH UNITS CAN BE PLACED SHOULD BE PROVIDED. | | THE [illegible] SHOULD BE PROVIDED WITH [illegible] TO AID IN ALIGNMENT OF THE [illegible] AND TO FACILITATE OVERALL [illegible]. | X | | | SEE 2.2. | 4 |
| | PAR. 4.2.1 | | [illegible] IS ONE OF THE GENERAL PRINCIPLES OF EQUIPMENT DESIGN FOR MAINTAINABILITY. [illegible] REQUIRES THAT EQUIPMENT BE DESIGNED TO PROVIDE FOR RAPID AND EASY REMOVAL AND REPLACEMENT OF UNITS BY A SINGLE OPERATOR, IF POSSIBLE. | [illegible]-180 | [illegible] WERE [illegible] TO THE PROCEDURE FOR THE [illegible] REPLACEMENT. | X | | | SEE 2.2. | 8 |
| | | | | [illegible]-180 SEE CHAPTER 12 FOR MORE DETAILED INFORMATION. | ADDITIONAL [illegible] WERE RECOMMENDED TO AID THE OPERATOR IN THE REMOVAL AND REPLACEMENT OF THE [illegible] FOR THE [illegible]. | 3 | | | SEE 2.2. | 8 |
| 2.5 HANDLING, TRANSPORTATION | PAR. 4.3.3.2 | | SPECIAL HANDLING EQUIPMENT SHOULD BE PROVIDED FOR EQUIPMENT WHICH IS NOT SMALL OR LIGHT ENOUGH FOR ONE MAN TO HANDLE AND CARRY. | TD 7.2.23 | [illegible] AND [illegible] WERE RECOMMENDED TO PERMIT [illegible] TO BE [illegible] FOR INSTALLATION AND REMOVAL OF THE [illegible]. | X | | | SEE 2.2. | 8 |
| 3.0 SAFETY FEATURES | | | | | | | | | | |
| 3.3 PROTECTION FROM ENTANGLEMENT | PAR. 7.4 | | PROVIDE A GUARD ON ALL MOVING PARTS OF MACHINERY AND TRANSMISSION EQUIPMENT IN WHICH PERSONNEL MAY BECOME INJURED OR ENTANGLED. | [illegible]-1065 | A COVER GUARD SHOULD BE PROVIDED FOR THE [illegible]. | X | | | [illegible] WAS SUBMITTED FOR A COVER GUARD. | 8 |

ITEM: [illegible]

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: CONTRACTUAL [illegible] | DOCUMENTARY COMPLIANCE: TECH REF | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION | VERIFICATION | VERIFICATION | RESULTS | [illegible] |
|---|---|---|---|---|---|---|---|---|---|---|
| 3.4 [illegible] | PAR. 7.4 | | [illegible] FORM OF ANCHOR [illegible] WITH HIGH CENTERS OF [illegible]. | TO 7.2.23 | [illegible] | X | | | SEE 2.2. | 8 |
| 3.5 SAFETY DEVICES ([illegible]) | PAR. 7.5 | | USE SELF-LOCKING OR OTHER FOOL-PROOF DEVICES TO PREVENT ACCIDENTAL MOVEMENT. | | A [illegible] SHOULD BE PROVIDED TO [illegible] | X | | | SEE 2.2. | 4 |
| | PAR. 7.2 | | THE OPERATION OF SWITCHES OR CONTROLS WHICH INITIATE HAZARDOUS OPERATIONS SHOULD REQUIRE THE PRIOR OPERATION OF A RELATED OR A LOCKING CONTROL. | TO 7.2.23 | [illegible] AS A [illegible] A. [illegible] B. [illegible] C. [illegible] D. [illegible] E. [illegible] | X | | | SEE 2.2. | 12 |

2.0 SYNOPSIS

ITEM: MAIN DRIVE

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: CONTRACTUAL REFERENCE | DOCUMENTARY COMPLIANCE: TECH. REF. | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION: ANAL | VERIFICATION: EQUIP | VERIFICATION: TEST | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| 3.5 SAFETY DEVICES (OTHER) CONT'D | | | | | [illegible] - SUPER CHARGE<br>[illegible] - HIGH PRESSURE<br>[illegible] - HIGH PRESSURE<br>[illegible] - HIGH PRESSURE<br>[illegible] - HIGH PRESSURE<br>[illegible] - SUPER CHARGE | | | | |
| 3.6 WARNING DEVICES | PAR. 7.1 | ASA Z53.1-1953 | INSURE THAT CONSPICUOUS PLACARDS ARE MOUNTED FOR CONDITIONS POTENTIALLY HAZARDOUS TO THE OPERATOR. | [illegible] | THE ANGLES LOCATED ON THE CATWALK SHOULD BE [illegible] MARKED TO [illegible] A TRIPPING POSSIBILITY. | X | | | |

2.0 SYNOPSIS

## 3.0 DISCUSSION

The Human Factors recommendations for the Main Drive are concerned with provisions for safe and efficient maintenance of the system components. Most of these tasks had not been evaluated as yet at the time of the preparation of this report.

One deficiency in the Main Drive design is the failure to provide an electric jacking motor for use as an auxiliary means of activating the launcher platform. This motor would have been used for two functions:

a. Activation of the launcher platform prior to the connection of the hydraulic system during installation.

b. Activation of the launcher platform in the event of a hydraulic failure. Access to the hydraulic motor and replacement will be difficult if a hydraulic failure occurs with the platform in the fully elevated position.

The addition of an electric jacking motor was proposed on an ECP to the Air Force but was rejected.

## 4.0 REFERENCES


1. AFBM Exhibit 57-8A, Human Engineering Design Standards for Missile System Equipment.

2. ASA Z53.1-1953, Safety Color Code for Marking Physical Hazards and the Identification of Certain Equipment.

3. AMF Report ER-TPS-#280, Field Evaluation, 5/4/60.

4. AMF Report ER-TPS-215, Launcher Drive Mechanism Cranking Provisions, June 2, 1959.

5. AMF Report MR-TPS-220, Jacking Motor - Cranking Provisions for the Main Platform Drive, 9/31/59.

6. AMF Document, TS 7.2.23, DDL Review, 12/18/59.

7. AMF Drawing HF-T-1065, Upper Silo Access Layout.

8. AMF Drawing No. HF-T-1034, Catwalk, Emergency Ladder (Quad. IV) to Bridge (Crib-to-Silo) OB.

9. AMF Drawing No. HF-T-1037, Access, Top of Silo (Quad. IV) TF & OB.

10. AMF Drawing No. HF-T-1042, Emergency Catwalk & Ladder Face C & D - OB.

11. AMF Drawing No. HF-T-1051, Platform, Access Cw't Support.

12. AMF Drawing No. HF-T-1052 - Counter-Weight Support Access Layout.

13. AMF Drawing No. HF-T-1055 - Platforms, Silo Upper Access.

14. AMF Drawing No. HF-T-1072 - Alternate Upper Silo Access Layout, OSTF.

15. AMF Drawing No. HF-T-1073 - Access Ladders and Work Platform #1 to Drive Base. TF & OB.

16. AMF Drawing No. HF-T-1076 - Upper Silo Access Layout, TF.

17. AMF Drawing No. HF-T-1090 - Stairway Study Elev. 380' to 392'.

18. AMF Drawing No. HF-T-1102 - Bridge Study Wire Rope Replacement.

19. AMF Drawing No. HF-T-1133 - Method for Replacement of Power Drive Motor (OSTF & TB).

20. AMF Drawing No. HF-T-1134 - Method for Replacement of Power Drive Motor (OSTF & TB).

21. AMF Drawing No. HF-T-1139 - Counterweight Show Replacement Study, TF & OB.

22. AMF Drawing No. HF-T-1146 - Spare Drive Motor Study.

# Chapter 22

## Human Factors Review and Evaluation of the Motor Control Center

INDICATOR LIGHTS

Amber lights would minimize accidental interruption of circuit.

CONTROLS

Locate controls for ease of use per AFBM Exhibit 57-8A.

DISPLAYS

Locate displays for ease of reading per AFBM Exhibit 57-8A.

OVERLOAD RELAYS

All units and parts should be identified.

FIGURE 22-1
HUMAN FACTORS INPUTS
MOTOR CONTROL CENTER

**SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO:**
THE MOTOR CONTROL CENTER

| | | Human Factor Effort Required | Phase II Stage: Concept | Phase II Stage: Review | Phase II Stage: Analysis | Phase II Stage: Field Input | Human Factors Objective: Specification Compliance | Human Factors Objective: Safety | Human Factors Objective: Operational Status | Human Factors Objective: Maintenance Recommendation | Human Factors Objective: Product Improvement | Applicable on Model: OSTF | Applicable on Model: TF | Applicable on Model: OB | Symbol |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1.0 HUMAN ENGINEERING DESIGN FACTORS** | | | | | | | | | | | | | |  |
| 1.1 | Anthropometric Compatability | * | | | | | * | | | | | * | * | * | |
| 1.2 | Controls and Displays | * | | | | | * | | | | | * | * | * | |
| 1.3 | Fail-Safe Design | * | | | | | * | * | | | | * | * | * | |
| 1.4 | Malfunction Detection | | | | | | | | | | | | | | |
| | **2.0 MAINTENANCE FACTORS** | | | | | | | | | | | | | |  |
| 2.1 | Access, Visual | | | | | | | | | | | | | | |
| 2.2 | Access, Servicing | | | | | | | | | | | | | | |
| 2.3 | Remove and Replace | * | | * | | | * | | | | | * | * | * | |
| 2.4 | Handling, Physical Limitations | * | | * | | | * | | | | | * | * | * | |
| 2.5 | Handling, Transportation | * | | * | | | * | | | | | * | * | * | |
| 2.6 | Vehicle Maneuverability | | | | | | | | | | | | | | |
| | **3.0 SAFETY FACTORS** | | | | | | | | | | | | | |  |
| 3.1 | Chemical Decontamination | | | | | | | | | | | | | | |
| 3.2 | Escape Provisions | | | | | | | | | | | | | | |
| 3.3 | Protection from Entanglement | | | | | | | | | | | | | | |
| 3.4 | Protection from Falling | | | | | | | | | | | | | | |
| 3.5 | Safety Devices (other) | * | * | * | | | * | * | | | | * | * | * | |
| 3.6 | Warning Devices | * | | * | | | * | * | | | | * | * | * | |
| | **4.0 PHYSIOLOGICAL FACTORS** | | | | | | | | | | | | | |  |
| 4.1 | Biological Damage | | | | | | | | | | | | | | |
| 4.2 | Vertigo | | | | | | | | | | | | | | |
| 4.3 | Vibration Effects | | | | | | | | | | | | | | |
| | **5.0 PSYCHOLOGICAL FACTORS** | | | | | | | | | | | | | |  |
| 5.1 | Fear of Heights | | | | | | | | | | | | | | |
| 5.2 | Fear of Being Crushed | | | | | | | | | | | | | | |
| 5.3 | Fear of Falling | | | | | | | | | | | | | | |
| 5.4 | Fear of Isolation | | | | | | | | | | | | | | |
| 5.5 | Feeling of Insecurity | | | | | | | | | | | | | | |
| | **6.0 ENVIRONMENTAL FACTORS** | | | | | | | | | | | | | |  |
| 6.1 | Acoustic Energy (noise) | | | | | | | | | | | | | | |
| 6.2 | Humidity & Temperature | | | | | | | | | | | | | | |
| 6.3 | Illumination | | | | | | | | | | | | | | |
| | **7.0 HUMAN USE FACTORS** | | | | | | | | | | | | | |  |
| 7.1 | Procedure | | | | | | | | | | | | | | |
| 7.2 | Time Study | | | | | | | | | | | | | | |
| 7.3 | Training/Selection | | | | | | | | | | | | | | |

FIGURE 22-2

## 1.0 DESCRIPTION

1.1 In this chapter, the human factors will be considered which are pertinent to the design and installation of the Motor Control Center.

The Motor Control Center conducts, transforms, rectifies and distributes electrical energy to supply the various needs of the Launcher System. Power is provided by others on a 3 phase, 480 volt, 60 cycle main bus. At this interface the Motor Control Center proceeds through its sub systems to distribute power as follows:

a) 480 volt, 3 phase, 60 cycle to hydraulic supply pump motors through circuit breakers and starters.

b) 120 volt, 60 cycle to motor starter control circuits and auxiliary uses through transformers and circuit breakers.

c) 28 volt DC to logic control circuitry through either one of two DC power supplies. Each power supply is individually fused to isolate it from the main supply in the event of malfunction. Automatic switching is provided on the output of the two 28 volt DC power supplies to transfer the DC load from the normal supply to the alternate supply in the event of failure of the normal unit.

d) 3 volt DC to test circuitry within the Logic System through a 3 volt DC Power Supply.

Three levels of protection are provided to the equipment receiving energy from this control center. Heater coils protect motor windings, overload relays protect circuitry, and circuit breakers protect the electrical system from the destructive burning effects of high current flow.

The actual hardware which comprises the Motor Control Center consists

of components such as circuit breakers, starters, transformers, rectifiers, buses and metering devices arranged within vertical racks completely enclosed on back and sides. Front door panels provide access to the various chassis and all cables and buses enter through the top. The entire unit is located within the Electrical Power and Control Room on the fourth level of the Equipment Terminal Silo.

1.2 Men of the Air Force population who represent body sizes between the 5th and 95th percentile must be able to operate the Motor Control Center efficiently without causing damage to equipment or injury to personnel. The equipment racks must be designed to provide adequate access to heater coils, overload relays and other parts requiring constant service, and where maintenance tasks require removal of components heavier than a man can safely lift special handling devices must be provided. Factors contributing to the successful use of the Motor Control Center have been itemized on the Summary Checklist (Fig. 22-2), and the progress of the Motor Control design has been tabulated in detail in the following Synopsis.

ITEM: MOTOR CONTROL CENTER

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE | | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA | | VERIFICATION | | | RESULTS | % RELATIVE VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| | CONTRACTUAL AFBM 57-8A | TECH. REF. | | PARTICIPATION | RECOMMENDATIONS | ANAL | EQUIP | TEST | | |
| 1.0 HUMAN ENGINEERING DESIGN<br>1.1 ANTHROPOMETRIC COMPATABILITY | PAR. 6.1.1<br>PAR. 6.1.2 | WADC-TR-52-321 | CONTROLS: (MANUAL)<br>MAXIMUM HEIGHT FROM FLOOR 70"<br>MINIMUM HEIGHT FROM FLOOR 30"<br>DISPLAYS: (VISUAL)<br>MAXIMUM HEIGHT FROM FLOOR 70"<br>MINIMUM HEIGHT FROM FLOOR 40" | DRAWING REVIEW RESULTED IN REPORT ER-TPS-224 | CONTROLS AND DISPLAYS SHOULD BE RELOCATED TO BRING THEM WITHIN THE OPTIMUM WORKING AREAS. | | X | | CHANGES NOT INCORPORATED BECAUSE A REQUIREMENT FOR AN OFF-THE-SHELF ITEM PREVAILED. | 20 |
| 1.2 CONTROLS AND DISPLAYS<br>1.2.1 CONSISTANT ARRANGEMENT | PAR. 2.1.4.3<br>PAR. 3.1.4.4 | WADC-TR-56-171<br>1.3 a<br>4.1 b | ARRANGE SIMILAR DISPLAYS CONSISTANTLY FROM APPLICATION TO APPLICATION. ARRANGE SIMILAR CONTROLS CONSISTANTLY FROM PANEL TO PANEL. | ER-TPS-224<br>A MAN-MACHINE ANALYSIS OF THE O.S.T.F. CONTROL AND DISPLAY ARRANGEMENT WAS PREPARED AS PART OF THE DESIGN EVALUATION. | DISPLAYS SHOULD BE ARRANGED CONSISTANTLY THROUGHOUT THE ENTIRE CONTROL CENTER | X | X | | RECOMMENDATION NOT ADOPTED - SCHEDULE WOULD NOT ALLOW CHANGE AND THE ITEM WOULD NO LONGER BE "OFF-THE-SHELF" | 5 |
| 1.2.2 COLOR CODING | PAR. 2.3.1.2 | | COLOR CODED LIGHTS SHALL BE USED AS FOLLOWS:<br>AMBER = HAZARDOUS CONDITION PREVAILS–DO NOT ACT WITHOUT CHECKING FOR PERMISSION.<br>RED TO INDICATE THAT MOTOR CONTROL CONTACTS ARE CLOSED & EQUIPMENT IS RUNNING ON THE LINE.<br>WHITE = INFORMATION<br>USE TO INDICATE THAT CIRCUIT BREAKER IS CLOSED AND POWER IS AVAILABLE. | ER-TPS-224<br>"FROM THE OPERATOR'S POINT OF VIEW THE ACTUAL CONTROL OF EQUIPMENT IS REMOTE AND HIS ONLY REACTION TO THIS DISPLAY SHOULD BE NEGATIVE OR 'DELAY' SINCE IT WOULD BE UNDESIRABLE TO BREAK A CIRCUIT WHILE EQUIPMENT IS RUNNING ON THE LINE". | CHANGE GREEN LIGHTS ON STARTER INDICATIONS TO AMBER. | X | X | | SAME AS ABOVE | 10 |
| 1.2.3 LABELING | PAR. 2.2.1<br>PAR. 2.2.2.4 | | CONTROLS AND DISPLAYS SHALL BE PROPERLY IDENTIFIED.<br>LABELS SHALL BE PERMANENTLY ATTACHED:<br>1. ETCHED OR ENGRAVED INTO PANEL FRONT<br>2. RIVETED OR CEMENTED PLATES | ER-TPS-224<br>REVIEW OF DRAWINGS REVEALED THE NEED FOR LABELS ON THE OVERLOAD RELAYS SPECIFICALLY. | FOLLOWING THE BASIC REQUIREMENTS OF THE REFERENCED DOCUMENT EACH OVERLOAD RESET PUSH BUTTON SHOULD BE DESCRIBED AS FOLLOWS:<br>"OVERLOAD RELAY"<br>PRESS TO RESET<br>ON AN ENGRAVED LABEL PERMANENTLY MOUNTED ABOVE EACH PUSH BUTTON. | | X | | NOT ADOPTED | 5 |



2.0 SYNOPSIS

ITEM: MOTOR CONTROL CENTER (CONTINUED)

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE | | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA | | VERIFICATION | | | RESULTS | RELATIVE VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| | CONTRACTUAL AFBM 57-8A | TECH. REF. | | PARTICIPATION | RECOMMENDATIONS | ANAL. | EQUIP. | TEST | | |
| 2.0 MAINTENANCE FACTORS | PAR. 4.3.3.1 | | COMPONENT WEIGHTS: KEEP REMOVABLE UNITS BELOW 35 LBS. FOR HANDLING AND CARRYING BY ONE MAN. INDICATE WEIGHT ON ALL COMPONENTS OVER 35 LBS. | CRITERIA PRESENTED TO HARDWARE GROUP IN CONSULTATION & HANDED DRAWINGS. | | | | | | |
| 2.3 REMOVE & REPLACE | | | PROVIDE SPECIAL HANDLING EQUIPMENT FOR ITEMS ABOVE THE FOLLOWING LIMITS:<br>MAX. WEIGHT / MAX. HEIGHT<br>142 / 1 FOOT<br>139 / 2<br>77 / 3<br>55 / 4<br>36 / 5<br>20 / 6 | | PROVIDE SPECIAL HANDLING EQUIPMENT (FOR DC POWER SUPPLIES SPECIFICALLY) | | | | NOT ADOPTED | 15 |
| 2.4 HANDLING, PHYSICAL LIMITATIONS | | | | COMPONENT WEIGHTS - UNITS SPARED & REQUIRING HANDLING IN REMOVE & REPLACE PROCEDURES<br>28 VDC POWER SUPPLY 215 LBS.<br>3 VDC POWER SUPPLY 941 LBS. | | | | | | 5 |
| 2.5 HANDLING, TRANSPORTATION | PAR. 4.3.3.1 | | HANDLING EQUIPMENT SHALL BE PROVIDED | | PROVIDE HANDLING EQUIPMENT AS INDICATED ABOVE | | | | | 5 |
| 3.0 SAFETY | | | | | | | | | | |
| 3.5 SAFETY DEVICES | PAR. 7.0 | | CIRCUIT BREAKER HANDLES SHALL BE PROVIDED WITH SOME METHOD FOR LOCKING IN THE 'OFF' POSITION. | EQUIPMENT WAS CONSIDERED IN ORIGINAL CONCEPT CRITERIA DRAWING REVIEW INDICATED THAT LOCKING CIRCUIT BREAKERS WERE BEING PROVIDED | PROVIDE CIRCUIT BREAKER HANDLES WHICH CAN BE LOCKED IN THE 'OFF' POSITION TO PROTECT PERSONNEL WORKING ON LINES AND EQUIPMENT | X | X | | ADOPTED | 20 |
| 3.6 WARNING DEVICES | PAR. 7.1 | A.S.A.-Z35.1 APPENDIX B AND D NAT. BUREAU OF STANDARDS HANDBOOK H-34 | PROVIDE "DANGER" SIGNS HIGH VOLTAGE FOR ALL COMPARTMENTS CARRYING A POTENTIAL OF MORE THAN 200 VOLTS. | | PROVIDE HIGH VOLTAGE SIGNS FOR ALL COMPARTMENTS WHERE THE POTENTIAL EXCEEDS 200 VOLTS | | | | NOT ADOPTED | 15 |

2.0 SYNOPSIS

## 3.0 DISCUSSION

3.1 Human Factors recommendations have been successfully included in the Motor Control Center:

a) Where criteria has been provided by the human factors engineers during the early concept stage, and

b) Where human factors features referenced within the guiding documents (AFBM-57-8A and others) have not been in conflict with the standard manufactured (off-the-shelf) philosophy of the missile program.

3.2 All of the recommendations indicated in the synopsis are still applicable to the Motor Control Center and should be included in the operational bases.

3.3 Where recommendations can not be included without extensive and costly modifications to equipment it is suggested that studies be performed in an effort to improve human factors conditions without involving a change to the existing hardware.

Studies of this nature could bring about improvements as indicated in the following example: The illustration (Fig. 22-1) indicates that many of the controls are above the maximum level for optimum operation as prescribed by the contractual documents. The panels at the bottom of the unit are infrequently used. A light weight removable platform approximately 10 inches in height and running the full length of the control station could be provided which would help bring the controls to within the reach of more of the Air Force population and would not interfere with any of the items mounted on low panel surfaces.

## 4.0 REFERENCES


1. AFBM Exhibit 57-8A, Human Engineering Design Standards for Missile System Equipment.

2. WADC TR 52-321, Anthropometry of Flying Personnel, 1959.

3. WADC TR 56-171, Layout of Work Places, 1959.

4. ASA Z35.1, Specifications for Industrial Accident Prevention Signs, 10 January 1941, R 1945.

5. U.S. Department of Commerce, National Bureau of Standards Handbook H34, Safety Rules for the Operation of Electrical Equipment and Lines, October 13, 1938.

6. AMF Report, ER-TPS-224, Motor Control Center - Human Factors Review-OSTF, 8/10/59.

# Chapter 23

## Human Factors Review and Evaluation of the Personnel Elevator

**ESCAPE METHOD**

An escape hatch has been provided in the elevator top.

**CONTROL ARRANGEMENT**

The control buttons have been arranged for optimum reach, readability, sequence, and priority based upon AFBM 57-8A and documents referenced therein.

**TELEPHONE HEIGHT**

The telephone has been raised (within design limitations) to improve dial reading and receiver reach.

**DOOR OPENINGS**

Entrances to the elevator car have been made 78" high to accommodate Air Force personnel in the 95th percentile group.

**CAR AND HOISTWAY GATES**

Gates have been provided at all entrances to the open hoistway and on the elevator car.

Gates meet A.S.A. design requirements and are electrically interlocked so that elevator cannot move while a gate is open and mechanically locked closed unless the car is available at a level.

**CALL BUTTONS**

Elevator call buttons have been placed 5' above each level in order to remove them from the path of vehicles and other equipment.

**EMERGENCY BRAKE**

Excessive dropping speeds are prevented by the use of a fail safe mechanical brake which is tripped when speeds exceed 175 f.p.m.

**ADDITIONAL STOP**

An additional elevator stop at the silo bottom level would eliminate many problems in emergency rescue operation and m intenance handling now depending upon special rigging procedures.

FIGURE 23-1.
HUMAN FACTORS INPUTS
PERSONNEL ELEVATOR

**SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO:**

PERSONNEL ELEVATOR

| | | Human Factor Effort Required | PHASE IN STAGE | | | | HUMAN FACTORS OBJECTIVE | | | | | APPLICABLE ON MODEL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Concept | Review | Analysis | Field Input | Specification Compliance | Safety | Operational Status | Maintenance Recommendation | Product Improvement | OSTF | TF | OB |
| | **1.0 HUMAN ENGINEERING DESIGN FACTORS** | | | | | | | | | | | | | |
| 1.1 | Anthropometric Compatability | * | * | * | * | | * | * | | | | * | * | * |
| 1.2 | Controls and Displays | * | * | * | * | | * | * | | | * | * | * | * |
| 1.3 | Fail-Safe Design | * | * | | * | | * | * | | | | * | * | * |
| 1.4 | Malfunction Detection | | | | | | | | | | | | | |
| | **2.0 MAINTENANCE FACTORS** | | | | | | | | | | | | | |
| 2.1 | Access, Visual | | | | | | | | | | | | | |
| 2.2 | Access, Servicing | * | * | * | * | * | * | * | | * | * | * | * | * |
| 2.3 | Remove and Replace | | | | | | | | | | | | | |
| 2.4 | Handling, Physical Limitations | | | | | | | | | | | | | |
| 2.5 | Handling, Transportation | | | | | | | | | | | | | |
| 2.6 | Vehicle Maneuverability | | | | | | | | | | | | | |
| | **3.0 SAFETY FACTORS** | | | | | | | | | | | | | |
| 3.1 | Chemical Decontamination | | | | | | | | | | | | | |
| 3.2 | Escape Provisions | * | * | * | | | * | * | | * | * | * | * | * |
| 3.3 | Protection from Entanglement | | | | | | | | | | | | | |
| 3.4 | Protection from Falling | * | * | * | | | * | * | | | * | * | * | * |
| 3.5 | Safety Devices (other) | * | * | * | | | * | * | | * | * | * | * | * |
| 3.6 | Warning Devices | * | * | * | | * | | * | | | * | * | * | * |
| | **4.0 PHYSIOLOGICAL FACTORS** | | | | | | | | | | | | | |
| 4.1 | Biological Damage | | | | | | | | | | | | | |
| 4.2 | Vertigo | | | | | | | | | | | | | |
| 4.3 | Vibration Effects | | | | | | | | | | | | | |
| | **5.0 PSYCHOLOGICAL FACTORS** | | | | | | | | | | | | | |
| 5.1 | Fear of Heights | * | * | * | * | | | * | | | | * | * | * |
| 5.2 | Fear of Being Crushed | | | | | | | | | | | | | |
| 5.3 | Fear of Falling | * | * | * | * | | | * | * | | | * | * | * |
| 5.4 | Fear of Isolation | * | * | * | * | | | * | | * | | * | * | * |
| 5.5 | Feeling of Insecurity | | | | | | | | | | | | | |
| | **6.0 ENVIRONMENTAL FACTORS** | | | | | | | | | | | | | |
| 6.1 | Acoustic Energy (noise) | | | | | | | | | | | | | |
| 6.2 | Humidity & Temperature | | | | | | | | | | | | | |
| 6.3 | Illumination | * | * | * | * | | * | * | | * | | * | * | * |
| | **7.0 HUMAN USE FACTORS** | | | | | | | | | | | | | |
| 7.1 | Procedure | | | | | | | | | | | | | |
| 7.2 | Time Study | | | | | | | | | | | | | |
| 7.3 | Training/Selection | | | | | | | | | | | | | |

FIGURE 23-2

## 1.0 DESCRIPTION

1.1 The Personnel Elevator is the basic means of vertical transportation for men and equipment to the various work platforms in the silo. It has two entrances (6' 3" wide x 6' 6" high) which are opposite each other. One entrance faces the crib and the other faces the access tunnel. The internal dimensions of the elevator are 6' 3" wide x 3' 6" deep x 7' 0" high. Its design is the single wrap traction sheave type and it is drive by an alternating-current electric motor. The elevator has a pushbutton control panel and is capable of stopping within 3/4" of the landing at any of its 8 stops. A hook is provided on the under side of the elevator which permits the attachment of a hoist or use of the elevator itself as a hoist for silo maintenance purposes.

### 1.2 Applicable Human Factors Considerations

Men of the Air Force population who represent body sizes between the 5th and 95th percentile must be able to handle the personnel elevator efficiently and safely. The elevator must be able to accept transporting vehicles (i.e. skids, dollys, etc.) and their loads, but is not required to take the Tug Truck or towing vehicle. Other considerations that contribute to the successful operation of the personnel elevator have been itemized on the summary checklist (Fig. 23-2) and tabulated in detail in the following synopsis.

ITEM: PERSONNEL ELEVATOR

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: CONTRACTUAL AFBM 57-8A | DOCUMENTARY COMPLIANCE: TECH. REF. | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION: ANAL | VERIFICATION: EQUIP | VERIFICATION: TEST | RESULTS | RELATIVE VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 HUMAN ENGINEERING DESIGN | PAR. 6.1.1 | | THE MINIMUM OVERHEAD HEIGHT REQUIREMENT IS 73". | | BOTH ENTRANCES ARE 70" HIGH AND THE CEILING IS 84" HIGH. | | X | | CRITERIA IS SATISFIED. | 5 |
| 1.1 ANTHROPOMETRIC COMPATABILITY | PAR. 6.1.2.2 | | STANDING OPERATION CONTROLS SHOULD BE NO HIGHER THAN 70" AND NO LOWER THAN 30". | | IT WAS RECOMMENDED THAT THE ELEVATOR CALL BUTTONS BE 5" ABOVE THE PLATFORM LEVEL. | X | | | RECOMMENDATION INCORPORATED. | 5 |
| | PAR. 6.1.2.1 | WADC TR 56-171 | VISUAL DISPLAYS SHOULD BE NO LOWER THAN 40" ABOVE THE STANDING SURFACE AND NO FURTHER THAN 28" FROM THE VIEWER'S EYE. | ER TPS #204 | IT WAS RECOMMENDED THAT THE TELEPHONE INSTALLATION BE RAISED IN HEIGHT (WITHIN THE DESIGN LIMITATIONS) TO PROVIDE BETTER DIAL VISIBILITY AND PERSONNEL COMFORT. (SEE 1.2 THIS SYNOPSIS). | X | | | THE TELEPHONE HAS BEEN ELEVATED. | 5 |
| 1.2 CONTROLS AND DISPLAYS | PAR. 3.1.4.1 | WADC-TR 56-171 | ALL CONTROLS HAVING SEQUENTIAL RELATION SHALL BE GROUPED TOGETHER. THE SEQUENCE SHOULD BE FROM LEFT TO RIGHT (HORIZONTAL) OR FROM TOP TO BOTTOM (VERTICAL), UNLESS CONTROL/DISPLAY ASSOCIATION IS VIOLATED THE CONTROLS SHOULD BE ALIGNED HORIZONTALLY. | ER-TPS-#204 | DEVIATION FROM THE STANDARD ELEVATOR PUSHBUTTON CONTROL PANEL WAS RECOMMENDED TO ACHIEVE OPTIMUM ARRANGEMENT OF ALL CONTROL PANEL COMPARTMENTS WITHIN THE ALLOTTED SPACE ENVELOPE. IT WAS RECOMMENDED THAT THE CONTROL PANEL BE REDESIGNED FROM A SINGLE VERTICAL ROW OF BUTTONS TO A SINGLE HORIZONTAL ROW OF BUTTONS NUMBERED SEQUENTIALLY FROM LEFT TO RIGHT (1 THRU 8). THIS WOULD ALLOW THE TELEPHONE TO BE ELEVATED. AN ALTERNATE RECOMMENDATION WAS A DOUBLE HORIZONTAL ROW NUMBERED 1 THRU 4 IN THE TOP ROW AND 5 THRU 8 IN THE SECOND ROW. | X | | | THE PANEL WAS REDESIGNED WITH THE BUTTONS IN A DOUBLE VERTICAL ROW PER MP-[illegible]. | 5 |

2.0 SYNOPSIS

ITEM: PERSONNEL ELEVATOR

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE | | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA | | VERIFICATION | | | RESULTS | % RELATIVE VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| | CONTRACTUAL AFBM 57-8A | TECH REF. | | PARTICIPATION | RECOMMENDATIONS | ANAL | EQUIP | TEST | | |
| 1.2 CONTROLS AND DISPLAYS (CONT'D) | PAR. 3.2.1.2.2 | WADC TR 56-171 PAR. 1.30 (REF. 84) | EMERGENCY BUTTONS SHOULD BE MUSHROOM SHAPED AND 3/4" DIAMETER MINIMUM. | | A THIRD AND FINAL RECOMMENDATION WAS MADE AND A LAYOUT SUBMITTED. THIS LAYOUT SHOWED A DOUBLE VERTICAL ROW OF BUTTONS NUMBERED TOP TO BOTTOM 1 THRU 4 (LEFT COLUMN) AND 5 THRU 8 (RIGHT COLUMN). ALSO SHOWN WAS THE 3/4" DIAMETER "STOP" BUTTON RELEASE BUTTON, AN ALARM BELL BUTTON, AND A LIGHT SWITCH. | | | | | |
| 1.3 FAIL SAFE DESIGN | PAR. 1.4 | | FAILURE OF ANY SINGLE CONTROLLING DEVICE OR SUPPORTING EQUIPMENT SHOULD NOT BE CAPABLE OF ALLOWING THE ELEVATOR TO FALL FREELY IN THE ELEVATOR SHAFT. | ER-TPS-#204 | THE ELEVATOR IS EQUIPPED WITH AN ELECTRICALLY RELEASED SPRING LOADED EMERGENCY BRAKE. THIS BRAKE IS MANUALLY RELEASED BY THE EMERGENCY STOP BUTTON AND AUTOMATICALLY RELEASED BY EITHER THE OVERSPEED GOVERNOR (WHICH TRIPS THE BRAKE WHEN THE ELEVATOR SPEED EXCEEDS 175 FPM) OR THE FINAL LIMIT SWITCHES WHICH ARE LOCATED JUST BEYOND THE TERMINAL LANDINGS. THE ONLY WAY TO RELEASE THE BRAKE ONCE SET IS TO APPLY POWER TO RAISE OR LOWER THE CAR. A MANUALLY OPERATED MECHANICAL INTERLOCK IS PROVIDED TO BE USED DURING ELEVATOR MAINTENANCE. | | | | CRITERIA SATISFIED | 20 |

2.0 SYNOPSIS

ITEM: PERSONNEL ELEVATOR

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: CONTRACTUAL AFBM 57-8A | DOCUMENTARY COMPLIANCE: TECH. REF. | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION: ANAL | VERIFICATION: EQUIP | VERIFICATION: TEST | RESULTS | RELATIVE VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.0 MAINTENANCE FACTORS<br>2.2 ACCESS, SERVICING | 4.3.3.9 | | AREAS OF THE ELEVATOR SUCH AS THE CONTROL PANEL AND DRIVE UNIT WHICH MAY REQUIRE FREQUENT OR REGULAR SERVICING SHOULD BE EASILY ACCESSIBLE. | SK-196-91137 | A DESIGN FOR AN ACCESS STAIRWAY TO THE SILO CATWALK HAS BEEN PROPOSED AT EL.389 QUAD. III. THIS STAIRWAY IS IN THE IMMEDIATE VICINITY OF THE ELEVATOR DRIVE UNIT AND WOULD PROVIDE ACCESS. THE CONTROL PANEL ON THE ELEVATOR IS DESIGNED TO HINGE OUT AND EXPOSE THE CHASSIS. THE EQUIPMENT ON THE TOPSIDE OF THE ELEVATOR IS ACCESSIBLE THROUGH THE HINGED PANEL IN THE CEILING. | X | | | NOT ADOPTED. | 5 |
| | | | | | THE ADDITION OF AN ELEVATOR STOP AT THE BASE OF THE SILO WAS RECOMMENDED TO IMPROVE MAINTENANCE AND ACCESS IN THAT AREA. ALSO CONSIDERED WAS THE REMOVAL OF INJURED PERSONNEL FROM THE BASE OF THE SILO. | X | | | SILO BOTTOM ELEVATOR STOP WAS NOT ADDED. AN ACCESS STAIRWAY HAS BEEN PROVIDED FROM ELEVATOR STOP #8 TO THE BASE OF THE SILO. | |

ITEM: PERSONNEL ELEVATOR

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: CONTRACTUAL AFBM 57-8A | DOCUMENTARY COMPLIANCE: TECH. REF. | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION: ANAL | VERIFICATION: EQUIP | VERIFICATION: TEST | RESULTS | RELATIVE VALUE % |
|---|---|---|---|---|---|---|---|---|---|---|
| 3.0 SAFETY<br>3.2 ESCAPE PROVISIONS | 7.12 | ASA A17.1<br>RULE 204.1E<br>(REF. #9) | A READILY ACCESSIBLE, UNOBSTRUCTED QUICK OPENING EMERGENCY EXIT MUST BE PROVIDED. THE DOOR OR HATCH SHOULD BE DESIGNED TO OPEN WITH A SINGLE MOTION OF THE HAND OR FOOT. | SA-TPS-#78 | THE ELEVATOR HAS A HINGED DOOR IN ITS CEILING. IT OPENS WITH AN UPWARD PUSH AND IS INTERLOCKED TO CUT OUT POWER TO THE MOTOR. IT WAS RECOMMENDED TO ADD TESTING OF THIS DOOR AND INTERLOCK TO THE QUALITY ASSURANCE TEST. A COLLAPSABLE LADDER IS PROVIDED FOR PERSONNEL TO CLIMB THROUGH THE EXIT. SINCE THE ESCAPE OPENING ALSO USED TO ALLOW CLEARANCE FOR LARGE ITEMS CARRIED IN THE ELEVATOR THE INTERLOCK SHOULD BE DEFEATABLE FOR THIS PURPOSE. | X | | | TOP HATCH HAS BEEN INCLUDED.<br>SAFETY INTERLOCK HAS NOT BEEN PROVIDED. | 10 |
| 3.4 PROTECTION FROM FALLING | 7.8, 7.9 | ASA A17.1<br>RULE 111.<br>& RULE 204.4<br>(REF. #9) | CAR GATES<br>1. SHOULD BE 5' HIGH MINIMUM.<br>2. SHOULD HAVE WIRE MESH WITH 2" DIAMETER BALL REJECTION.<br>3. SHOULD BE INTERLOCKED TO PREVENT ELEVATOR OPERATION WHEN NOT COMPLETELY CLOSED.<br>4. SHOULD BE INTERLOCKED TO OPEN ONLY WHEN THE ELEVATOR IS AT A LANDING.<br>HOISTWAY GATES<br>5. SHOULD COMPLETELY COVER HOISTWAY ENTRANCE.<br>6. SHOULD BE INTERLOCKED TO PREVENT ELEVATOR OPERATION WHEN NOT COMPLETELY CLOSED.<br>7. SHOULD BE INTERLOCKED TO OPEN ONLY WHEN THE ELEVATOR IS STOPPED AT THE LANDING | SA-TPS-78 | THE CAR GATES AND THE HOISTWAY GATES ARE ADEQUATELY INTERLOCKED. THE HOISTWAY GATES COMPLETELY COVER THE SHAFTWAY OPENINGS. THE INITIAL HOISTWAY GATE LOCATION AT STOP #3 (ACCESS TUNNEL-CRIB TO SILO BRIDGE) WAS SUCH THAT AN OPERATOR MIGHT BE CAUGHT BETWEEN THE GATE AND THE OPEN ELEVATOR SHAFT SHOULD THE CAR BE CALLED AWAY. A RECOMMENDATION FOR A LEVER LINKAGE DESIGN ALLOWING THE GATE TO BE CLOSED FROM THE CAR SHOULD BE INVESTIGATED. ALSO RECOMMENDED WAS THE ADDITION OF A SECOND GATE ON THE ELEVATOR SIDE OF THE BRIDGE. | X | | | THE HOISTWAY GATE AT STOP #3 WAS RELOCATED AND MOUNTED ON THE CRIB ELIMINATING THE POSSIBILITY OF AN OPERATOR BEING EXPOSED TO THE OPEN SHAFTWAY. THE CAR GATE DIMENSIONS AND MESH SIZE ARE SATISFACTORY. | 10 |

2.0 SYNOPSIS

ITEM: PERSONNEL ELEVATOR

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE | | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA | | VERIFICATION | | | RESULTS | % RELATIVE VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| | CONTRACTUAL AFBM 57-9A | TECH. REF. | | PARTICIPATION | RECOMMENDATIONS | ANAL | EQUIP | TEST | | |
| 3.4 PROTECTION FROM FALLING (CONT'D) | | | WHICH THE GATE SERVICES. | | A RECOMMENDATION TO ADD THE CAR GATE HEIGHT DIMENSION AND THE WIRE MESH SIZE TO THE ACCEPTANCE TESTS WAS MADE. | | | | | |
| 3.5 SAFETY DEVICES | | ABS 2002 (REF. #13) ASA -A17.1 (REF. #4) | HANDRAILS SHOULD BE PROVIDED IN THE ELEVATOR CAR. | HB-TPS-#204 | HANDRAILS 42" FROM THE FLOOR SHOULD BE PROVIDED AND MOUNTED SO AS NOT TO INTERFERE WITH THE CONTROL PANEL OR TELEPHONE. | X | | | A RAIL HAS BEEN PROVIDED ON ONE SIDE ONLY (OPPOSITE CONTROL PANEL) WHICH DOES NOT CONFORM TO ASA SPECIFICATIONS | 5 |
| | | AFM-3002A | AN EMERGENCY SITUATION REQUIRES FAST POSITIVE ACTION. | HF-T-1001 | METHOD OF CONTROLS LAYOUT W/ENLARGED EMERGENCY STOP BUTTON AND FLOOR LEVEL BUTTONS IN VERTICAL ORDER. | X | | | INSTALLED - GIVES BETTER RELATIONSHIP BETWEEN LEVELS AND CONTROLS. | |
| | 7.2 | | | | SWITCH AT THE ESCAPE HATCH TO SHUT OFF POWER IF HATCH IS LIFTED - BUT SHOULD BE OF THE REMOVABLE TYPE AS THIS HATCH IS ALSO USED FOR OVERSIZED EQUIPMENT. | X | | | A FIELD CHECK INDICATES THAT THE SAFETY SWITCH INTERLOCK HAS NOT BEEN PROVIDED. | 5 |
| 3.6 WARNING DEVICES | 7.17 | | AN AUDIBLE WARNING DEVICE GIVES SOME GENERAL COVERAGE WITH THIS PIECE OF EQUIPMENT. LOCATION AND SIZE OF CAPACITY RATING SIGN. | | A WARNING BELL TO CALL ATTENTION TO THE ELEVATOR WHEN IN OPERATION. INDICATE THE WEIGHT CAPACITY TO HELP PREVENT OVERLOADING. | X | | | INSTALLED. | 5 |
| 5.0 PSYCHOLOGICAL FACTORS 5.1 FEAR OF HEIGHTS | | | | HB-TPS-78 | OPAQUE SCREENING TO REDUCE FEAR OF HEIGHT TOP, SIDES, AND 3/4 UP ON GATES. | X | X | | NO OPAQUE MATERIAL HAS BEEN INSTALLED ON THE GATES. | 5 |

ITEM: PERSONNEL ELEVATOR

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE | | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA | | VERIFICATION | | | RESULTS | % RELATIVE VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| | CONTRACTUAL AFBM 57-8A | TECH. REF. | | PARTICIPATION | RECOMMENDATIONS | ANAL | EQUIP | TEST | | |
| 5.3 FEAR OF FALLING | | | | [illegible]-TPS-78 | SEE ABOVE (5.1) | X | X | | SEE ABOVE. | |
| 5.4 FEAR OF ISOLATION | SEE CHAPTER 8 SECTION 5.4. | | SEE CHAPTER 8, SECTION 5.4. | SEE CHAPTER 8, SECTION 5.4. | TELEPHONE INSTALLED TO PREVENT ISOLATION BETWEEN FLOORS DUE TO POWER FAILURE. | | | | INSTALLED. | 10 |
| 6.0 ENVIRONMENTAL FACTORS | | | | | | | | | | |
| 6.3 ILLUMINATION | 7.22 | APS-2002 | ALL WORK AREAS SHOULD BE ILLUMINATED BY AT LEAST 25 FOOT CANDLES. | | LIGHTING FIXTURES WILL BE FULLY RECESSED IN THE CEILING OF ELEVATOR. | X | X | | INSTALLED. | 5 |
| | | | | | | | | | | 100 |

2.0 SYNOPSIS

3.0 <u>DISCUSSION</u>

3.1 The Personnel Elevator should be improved by considering the following modifications in the design. The load capacity should be increased so that more equipment and personnel can be transported without approaching the limit of rated capacity. If the Personnel Elevator could be provided with a stop at the bottom (e.g. elevation 255'-4") many of the present handling problems in the lower silo area would have been simplified. By having the elevator stop at the grating elevation, injured personnel as well as heavy components could be handled more easily without special equipment brought in for the emergency.

The method of escape from the Personnel Elevator leaves the personnel involved in a precarious position on top of the elevator. A safe escape method from the elevator top should be provided, otherwise personnel will be in greater danger should they use such a limited escape procedure.

3.2 These Human Factors recommendations apply to the training and operational bases as they now exist, and should apply to future design specifications for Personnel Elevators in any system.

## 4.0 REFERENCES


1. AFBM 57-8A, Human Engineering Design Standards for Missile System Equipment.

2. WADC TR 56-171, Layout of Workplaces, Chapter V of the Joint Services Human Engineering Guide to Equipment Design.

3. ASA A17.1, American Standards Safety Code for Elevators.

4. ADS 2002A, Personnel Elevator for WS 107A-2 Launcher System.

5. APS-2002A, Personnel Elevator for WS 107A-2 Launcher System.

6. AMF Procurement Specification - 2302, 1/18/60.

7. AMF Report, ER-TPS-204, Evaluation of Personnel Elevator for WS 107A-2 Launcher System for TB & OB, 4/17/59.

8. AMF Report, ER-TPS-78, Personnel Elevator - Human Factors Requirements, 7/14/58.

9. AMF Drawing No. SK-194-91137, Emergency Ladder-W.P. #3 to Top of Silo, Quad, III, Face "C".

10. AMF Drawing No. HF-T-1001, Personnel Elevator Controls (Recommended Arrangement).

11. AMF Drawing No. HF-T-1032, Clearance Between Sheave and Hand Rail.

12. AMF Drawing No. HF-T-1077, Personnel Elevator Envelope Study for TF & OB.

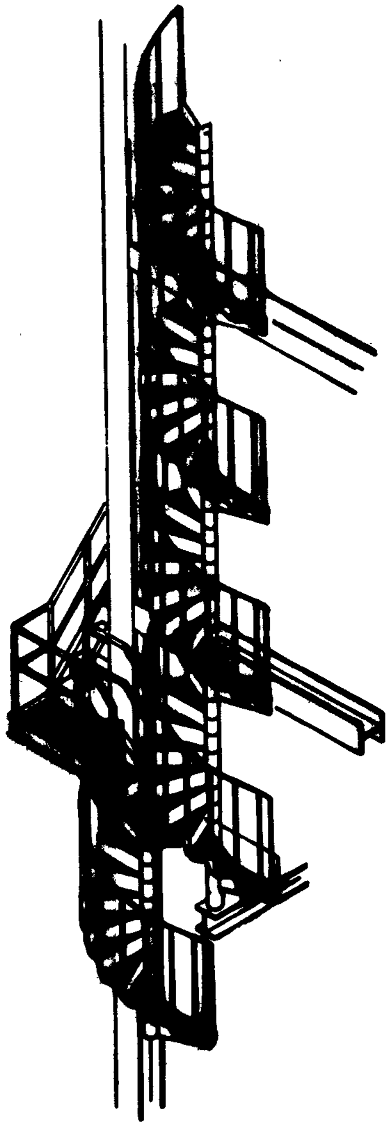
13. AMF Drawing No. HF-T-1130, Personnel Elevator Call Button Locations.

14. AMF Drawing No. HF-T-1145, Personnel Elevator Controls & Telephone Envelope.

15. AMF Drawing No. HF-T-1151, Elevator Call Button - OSTF Tunnel Entrance.

# Chapter 24

## Human Factors Review and Evaluation of the Safety Equipment



**TRAINING ACCESS**

The personnel stairway provides easy access to work platform levels during training procedures.

FIGURE 24-1
HUMAN FACTORS INPUTS
PERSONNEL STAIRWAY

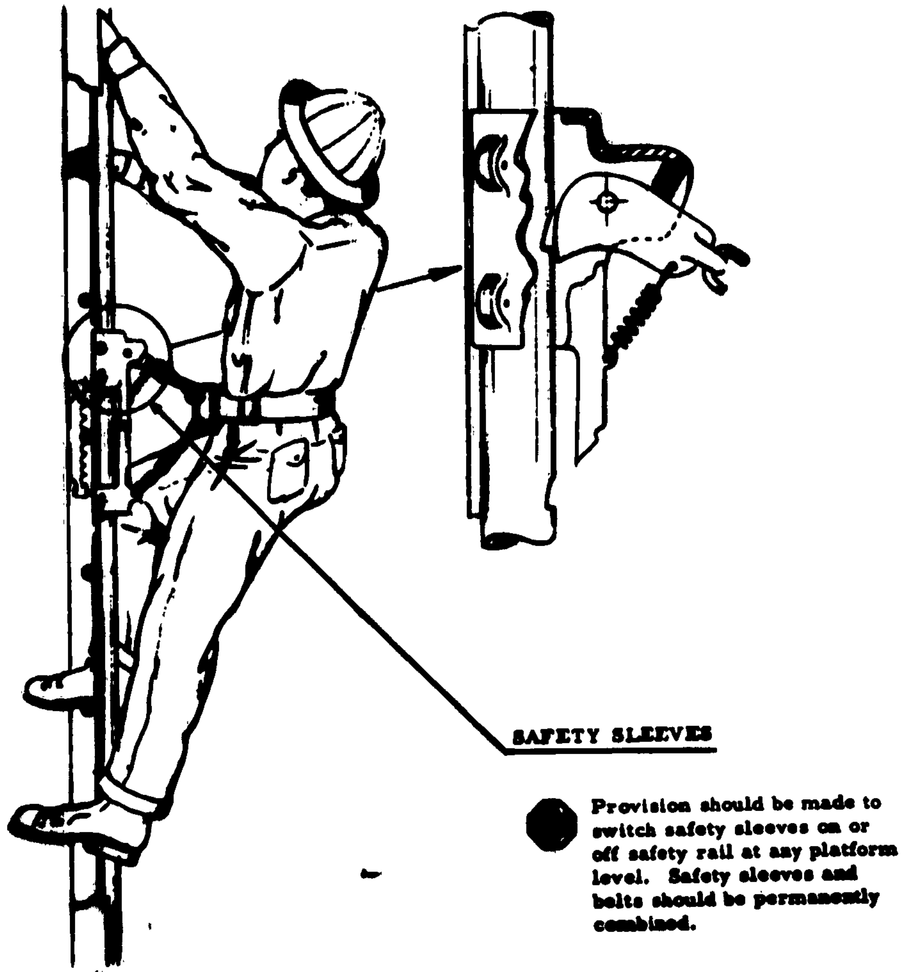
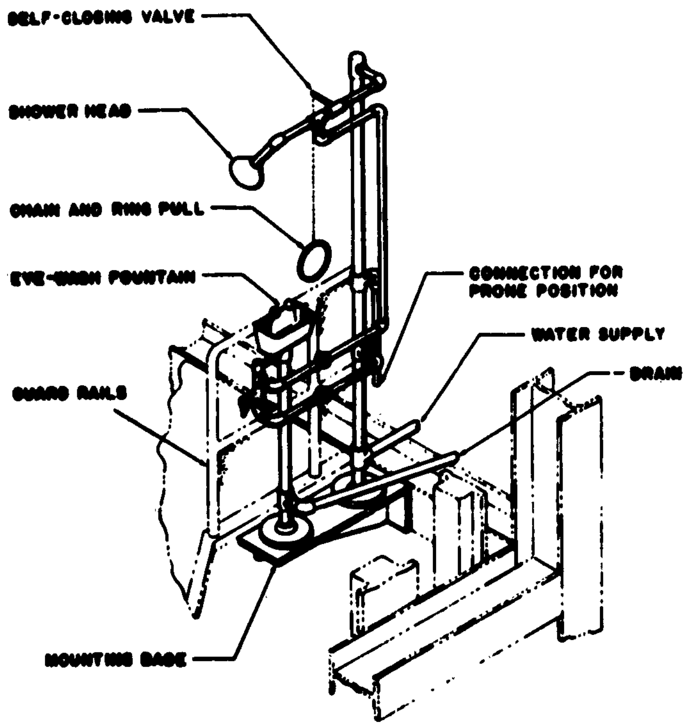



FIGURE 24-2
HUMAN FACTORS INPUTS
EMERGENCY LADDER
SAFETY RAIL & SLEEVE




ORIENTATION

**Emergency shower and eye-wash stations should be identically located on each work platform level.**

FIGURE 24-3
**HUMAN FACTORS INPUTS**
**SHOWER AND EYEWASH**
**STATIONS**

**SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO:**
PERSONNEL STAIRWAY

| | | Human Factor Effort Required | PHASE II STAGE: Concept | Review | Analysis | Field Input | HUMAN FACTORS OBJECTIVE: Specification Compliance | Safety | Operational Status | Maintenance Recommendation | Product Improvement | APPLICABLE ON MODEL: OSTF | TF | OB | SYMBOL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | **HUMAN ENGINEERING DESIGN FACTORS** | | | | | | | | | | | | | | |
| 1.1 | **Anthropometric Compatability** | * | * | * | | | * | * | | | | * | * | | |
| 1.2 | **Controls and Displays** | | | | | | | | | | | | | | |
| 1.3 | **Fail-Safe Design** | | | | | | | | | | | | | | |
| 1.4 | **Malfunction Detection** | | | | | | | | | | | | | | |
| 2.0 | **MAINTENANCE FACTORS** | | | | | | | | | | | | | | |
| 2.1 | **Access, Visual** | * | * | * | | | * | * | | | | * | * | | |
| 2.2 | **Access, Servicing** | * | * | * | | | * | * | | | | * | * | | |
| 2.3 | **Remove and Replace** | | | | | | | | | | | | | | |
| 2.4 | **Handling, Physical Limitations** | | | | | | | | | | | | | | |
| 2.5 | **Handling, Transportation** | | | | | | | | | | | | | | |
| 2.6 | **Vehicle Maneuverability** | | | | | | | | | | | | | | |
| 3.0 | **SAFETY FACTORS** | | | | | | | | | | | | | | |
| 3.1 | **Chemical Decontamination** | | | | | | | | | | | | | | |
| 3.2 | **Escape Provisions** | * | * | * | | | * | * | | | | * | * | | |
| 3.3 | **Protection from Entanglement** | | | | | | | | | | | | | | |
| 3.4 | **Protection from Falling** | * | * | * | | | * | * | | | | * | * | | |
| 3.5 | **Safety Devices (other)** | | | | | | | | | | | | | | |
| 3.6 | **Warning Devices** | | | | | | | | | | | | | | |
| 4.0 | **PHYSIOLOGICAL FACTORS** | | | | | | | | | | | | | | |
| 4.1 | **Biological Damage** | | | | | | | | | | | | | | |
| 4.2 | **Vertigo** | | | | | | | | | | | | | | |
| 4.3 | **Vibration Effects** | | | | | | | | | | | | | | |
| 5.0 | **PSYCHOLOGICAL FACTORS** | | | | | | | | | | | | | | |
| 5.1 | **Fear of Heights** | | | | | | | | | | | | | | |
| 5.2 | **Fear of Being Crushed** | | | | | | | | | | | | | | |
| 5.3 | **Fear of Falling** | * | * | * | | | * | * | | | | * | * | | |
| 5.4 | **Fear of Isolation** | | | | | | | | | | | | | | |
| 5.5 | **Feeling of Insecurity** | * | * | * | | | * | * | | | | * | * | | |
| 6.0 | **ENVIRONMENTAL FACTORS** | | | | | | | | | | | | | | |
| 6.1 | **Acoustic Energy (noise)** | | | | | | | | | | | | | | |
| 6.2 | **Humidity & Temperature** | | | | | | | | | | | | | | |
| 6.3 | **Illumination** | | | | | | | | | | | | | | |
| 7.0 | **HUMAN USE FACTORS** | | | | | | | | | | | | | | |
| 7.1 | **Procedure** | * | * | * | | | | * | | | | * | * | | |
| 7.2 | **Time Study** | | | | | | | | | | | | | | |
| 7.3 | **Training/Selection** | * | * | * | | | * | * | | | | * | * | | |

FIGURE 24-4
SAFETY EQUIPMENT

**SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO:**
BOTTOM ACCESS STAIRWAY

| No. | Item | Human Factor Effort Required | Concept (Phase in Stage) | Review (Phase in Stage) | Analysis (Phase in Stage) | Field Input (Phase in Stage) | Specification Compliance (Human Factors Objective) | Safety (Human Factors Objective) | Operational Status (Human Factors Objective) | Maintenance Recommendation (Human Factors Objective) | Product Improvement (Human Factors Objective) | OSTF (Applicable on Model) | TF (Applicable on Model) | OB (Applicable on Model) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | HUMAN ENGINEERING DESIGN FACTORS | | | | | | | | | | | | | |
| 1.1 | Anthropometric Compatability | * | | | * | | * | * | | * | | * | * | * |
| 1.2 | Controls and Displays | | | | | | | | | | | | | |
| 1.3 | Fail-Safe Design | | | | | | | | | | | | | |
| 1.4 | Malfunction Detection | | | | | | | | | | | | | |
| 2.0 | MAINTENANCE FACTORS | | | | | | | | | | | | | |
| 2.1 | Access, Visual | * | | | * | | * | * | | * | | * | * | * |
| 2.2 | Access, Servicing | * | | | * | | * | * | | * | | * | * | * |
| 2.3 | Remove and Replace | * | | | * | | * | | | * | | * | * | * |
| 2.4 | Handling, Physical Limitations | * | | | * | | * | | | * | | * | * | * |
| 2.5 | Handling, Transportation | * | | | | | | | | * | | * | * | * |
| 2.6 | Vehicle Maneuverability | | | | | | | | | | | | | |
| 3.0 | SAFETY FACTORS | | | | | | | | | | | | | |
| 3.1 | Chemical Decontamination | | | | | | | | | | | | | |
| 3.2 | Escape Provisions | * | | | * | | * | * | | * | | * | * | * |
| 3.3 | Protection from Entanglement | | | | | | | | | | | | | |
| 3.4 | Protection from Falling | * | | | * | | * | * | | * | | * | * | * |
| 3.5 | Safety Devices (other) | | | | | | | | | | | | | |
| 3.6 | Warning Devices | | | | | | | | | | | | | |
| 4.0 | PHYSIOLOGICAL FACTORS | | | | | | | | | | | | | |
| 4.1 | Biological Damage | | | | | | | | | | | | | |
| 4.2 | Vertigo | | | | | | | | | | | | | |
| 4.3 | Vibration Effects | | | | | | | | | | | | | |
| 5.0 | PSYCHOLOGICAL FACTORS | | | | | | | | | | | | | |
| 5.1 | Fear of Heights | | | | | | | | | | | | | |
| 5.2 | Fear of Being Crushed | | | | | | | | | | | | | |
| 5.3 | Fear of Falling | * | | | * | | | * | | * | | * | * | * |
| 5.4 | Fear of Isolation | | | | | | | | | | | | | |
| 5.5 | Feeling of Insecurity | * | | | * | | | * | | * | | | | * |
| 6.0 | ENVIRONMENTAL FACTORS | | | | | | | | | | | | | |
| 6.1 | Acoustic Energy (noise) | | | | | | | | | | | | | |
| 6.2 | Humidity & Temperature | | | | | | | | | | | | | |
| 6.3 | Illumination | | | | | | | | | | | | | |
| 7.0 | HUMAN USE FACTORS | | | | | | | | | | | | | |
| 7.1 | Procedure | | | | | | | | | | | | | |
| 7.2 | Time Study | | | | | | | | | | | | | |
| 7.3 | Training/Selection | | | | | | | | | | | | | |

SYMBOL

FIGURE 24-5
SAFETY EQUIPMENT

**SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO:**
EMERGENCY LADDER

| | | | PHASE IN STAGE | | | | HUMAN FACTORS OBJECTIVE | | | | | APPLICABLE ON MODEL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Human Factor Effort Required | Concept | Review | Analysis | Field Input | Specification Compliance | Safety | Operational Status | Maintenance Recommendation | Product Improvement | OSTF | TF | OB | SYMBOL |
| | **1.0 HUMAN ENGINEERING DESIGN FACTORS** | | | | | | | | | | | | | |  |
| 1.1 | **Anthropometric Compatability** | * | * | * | | | * | * | | | | * | * | * | |
| 1.2 | **Controls and Displays** | | | | | | | | | | | | | | |
| 1.3 | **Fail-Safe Design** | | | | | | | | | | | | | | |
| 1.4 | **Malfunction Detection** | | | | | | | | | | | | | | |
| | **2.0 MAINTENANCE FACTORS** | | | | | | | | | | | | | |  |
| 2.1 | **Access, Visual** | | | | | | | | | | | | | | |
| 2.2 | **Access, Servicing** | | | | | | | | | | | | | | |
| 2.3 | **Remove and Replace** | | | | | | | | | | | | | | |
| 2.4 | **Handling, Physical Limitations** | | | | | | | | | | | | | | |
| 2.5 | **Handling, Transportation** | | | | | | | | | | | | | | |
| 2.6 | **Vehicle Maneuverability** | | | | | | | | | | | | | | |
| | **3.0 SAFETY FACTORS** | | | | | | | | | | | | | |  |
| 3.1 | **Chemical Decontamination** | | | | | | | | | | | | | | |
| 3.2 | **Escape Provisions** | * | * | | | | * | * | | | | * | * | * | |
| 3.3 | **Protection from Entanglement** | | | | | | | | | | | | | | |
| 3.4 | **Protection from Falling** | * | * | | | | | | | | | | | | |
| 3.5 | **Safety Devices (other)** | * | | * | | | * | * | | | | * | * | * | |
| 3.6 | **Warning Devices** | | | | | | | * | | | | * | * | * | |
| | **4.0 PHYSIOLOGICAL FACTORS** | | | | | | | | | | | | | |  |
| 4.1 | **Biological Damage** | | | | | | | | | | | | | | |
| 4.2 | **Vertigo** | | | | | | | | | | | | | | |
| 4.3 | **Vibration Effects** | | | | | | | | | | | | | | |
| | **5.0 PSYCHOLOGICAL FACTORS** | | | | | | | | | | | | | |  |
| 5.1 | **Fear of Heights** | | | | | | | | | | | | | | |
| 5.2 | **Fear of Being Crushed** | | | | | | | | | | | | | | |
| 5.3 | **Fear of Falling** | * | * | | | | * | * | | | | * | * | * | |
| 5.4 | **Fear of Isolation** | * | * | | | | | * | | | | * | * | * | |
| 5.5 | **Feeling of Insecurity** | * | * | | | | | * | | | | * | * | * | |
| | **6.0 ENVIRONMENTAL FACTORS** | | | | | | | | | | | | | |  |
| 6.1 | **Acoustic Energy (noise)** | | | | | | | | | | | | | | |
| 6.2 | **Humidity & Temperature** | | | | | | | | | | | | | | |
| 6.3 | **Illumination** | | | | | | | | | | | | | | |
| | 7.0 HUMAN USE FACTORS | | | | | | | | | | | | | |  |
| 7.1 | Procedure | | | | | | | | | | | | | | |
| 7.2 | Time Study | | | | | | | | | | | | | | |
| 7.3 | Training/Selection | | | | | | | | | | | | | | |

FIGURE 24-6
SAFETY EQUIPMENT

**SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO:**
GUARD RAILS AND SAFETY GATES

| | | PHASE IN STAGE | | | | HUMAN FACTORS OBJECTIVE | | | | | APPLICABLE ON MODEL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Human Factor Effort Required | Concept | Review | Analysis | Field Input | Specification Compliance | Safety | Operational Status | Maintenance Recommendation | Product Improvement | OSTF | TF | OB | SYMBOL |
| **1.0 HUMAN ENGINEERING DESIGN FACTORS** | | | | | | | | | | | | | | |
| **1.1 Anthropometric Compatability** | * | * | | | | * | * | | | | * | * | * | |
| **1.2 Controls and Displays** | | | | | | | | | | | | | | |
| **1.3 Fail-Safe Design** | | | | | | | | | | | | | | |
| **1.4 Malfunction Detection** | | | | | | | | | | | | | | |
| **2.0 MAINTENANCE FACTORS** | | | | | | | | | | | | | | |
| **2.1 Access, Visual** | | | | | | | | | | | | | | |
| **2.2 Access, Servicing** | | | | | | | | | | | | | | |
| **2.3 Remove and Replace** | | | | | | | | | | | | | | |
| **2.4 Handling, Physical Limitations** | | | | | | | | | | | | | | |
| **2.5 Handling, Transportation** | | | | | | | | | | | | | | |
| **2.6 Vehicle Maneuverability** | | | | | | | | | | | | | | |
| **3.0 SAFETY FACTORS** | | | | | | | | | | | | | | |
| **3.1 Chemical Decontamination** | | | | | | | | | | | | | | |
| **3.2 Escape Provisions** | | | | | | | | | | | | | | |
| **3.3 Protection from Entanglement** | | | | | | | | | | | | | | |
| **3.4 Protection from Falling** | * | * | | | | * | * | | | | * | * | * | |
| **3.5 Safety Devices (other)** | | | | | | | | | | | | | | |
| **3.6 Warning Devices** | | | | | | | | | | | | | | |
| **4.0 PHYSIOLOGICAL FACTORS** | | | | | | | | | | | | | | |
| **4.1 Biological Damage** | | | | | | | | | | | | | | |
| **4.2 Vertigo** | | | | | | | | | | | | | | |
| **4.3 Vibration Effects** | | | | | | | | | | | | | | |
| **5.0 PSYCHOLOGICAL FACTORS** | | | | | | | | | | | | | | |
| **5.1 Fear of Heights** | | | | | | | | | | | | | | |
| **5.2 Fear of Being Crushed** | | | | | | | | | | | | | | |
| **5.3 Fear of Falling** | * | * | | | | * | * | | | | * | * | * | |
| **5.4 Fear of Isolation** | | | | | | | | | | | | | | |
| **5.5 Feeling of Insecurity** | * | * | | | | * | * | | | | * | * | * | |
| **6.0 ENVIRONMENTAL FACTORS** | | | | | | | | | | | | | | |
| **6.1 Acoustic Energy (noise)** | | | | | | | | | | | | | | |
| **6.2 Humidity & Temperature** | | | | | | | | | | | | | | |
| **6.3 Illumination** | | | | | | | | | | | | | | |
| **7.0 HUMAN USE FACTORS** | | | | | | | | | | | | | | |
| **7.1 Procedure** | | | | | | | | | | | | | | |
| **7.2 Time Study** | | | | | | | | | | | | | | |
| **7.3 Training/Selection** | | | | | | | | | | | | | | |

FIGURE 24-7
SAFETY EQUIPMENT

SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO:
SAFETY NETS

| | | Human Factor Effort Required | PHASE IN STAGE: Concept | Review | Analysis | Field Input | HUMAN FACTORS OBJECTIVE: Specification Complicance | Safety | Operational Status | Maintenance Recommendation | Product Improvement | APPLICABLE ON MODEL: OSTF | TF | OB | SYMBOL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1.0 HUMAN ENGINEERING DESIGN FACTORS** | | | | | | | | | | | | | |  |
| 1.1 | **Anthropometric Compatability** | * | * | | * | | * | * | | | | * | * | * | |
| 1.2 | **Controls and Displays** | | | | | | | | | | | | | | |
| 1.3 | **Fail-Safe Design** | | | | | | | | | | | | | | |
| 1.4 | **Malfunction Detection** | | | | | | | | | | | | | | |
| | **2.0 MAINTENANCE FACTORS** | | | | | | | | | | | | | |  |
| 2.1 | **Access, Visual** | | | | | | | | | | | | | | |
| 2.2 | **Access, Servicing** | | | | | | | | | | | | | | |
| 2.3 | **Remove and Replace** | | | | | | | | | | | | | | |
| 2.4 | **Handling, Physical Limitations** | | | | | | | | | | | | | | |
| 2.5 | **Handling, Transportation** | | | | | | | | | | | | | | |
| 2.6 | **Vehicle Maneuverability** | | | | | | | | | | | | | | |
| | **3.0 SAFETY FACTORS** | | | | | | | | | | | | | |  |
| 3.1 | **Chemical Decontamination** | | | | | | | | | | | | | | |
| 3.2 | **Escape Provisions** | | | | | | | | | | | | | | |
| 3.3 | **Protection from Entanglement** | | | | | | | | | | | | | | |
| 3.4 | **Protection from Falling** | * | | | * | | * | * | | | | * | * | * | |
| 3.5 | **Safety Devices (other)** | | | | | | | | | | | | | | |
| 3.6 | **Warning Devices** | | | | | | | | | | | | | | |
| | **4.0 PHYSIOLOGICAL FACTORS** | | | | | | | | | | | | | |  |
| 4.1 | **Biological Damage** | | | | | | | | | | | | | | |
| 4.2 | **Vertigo** | | | | | | | | | | | | | | |
| 4.3 | **Vibration Effects** | | | | | | | | | | | | | | |
| | **5.0 PSYCHOLOGICAL FACTORS** | | | | | | | | | | | | | |  |
| 5.1 | **Fear of Heights** | | | | | | | | | | | | | | |
| 5.2 | **Fear of Being Crushed** | | | | | | | | | | | | | | |
| 5.3 | **Fear of Falling** | * | | | * | | * | * | | | | * | * | * | |
| 5.4 | **Fear of Isolation** | | | | | | | | | | | | | | |
| 5.5 | **Feeling of Insecurity** | * | | | * | | | * | | | | * | * | * | |
| | **6.0 ENVIRONMENTAL FACTORS** | | | | | | | | | | | | | |  |
| 6.1 | **Acoustic Energy (noise)** | | | | | | | | | | | | | | |
| 6.2 | **Humidity & Temperature** | | | | | | | | | | | | | | |
| 6.3 | **Illumination** | | | | | | | | | | | | | | |
| | **7.0 HUMAN USE FACTORS** | | | | | | | | | | | | | |  |
| 7.1 | **Procedure** | | | | | | | | | | | | | | |
| 7.2 | **Time Study** | | | | | | | | | | | | | | |
| 7.3 | **Training/Selection** | | | | | | | | | | | | | | |

FIGURE 24-8
SAFETY EQUIPMENT

**SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO:**
MAIN CLOSURE DOOR
KLAXON

| | Human Factor Effort Required | PHASE IN STAGE: Concept | Review | Analysis | Field Input | HUMAN FACTORS OBJECTIVE: Specification Compliance | Safety | Operational Status | Maintenance Recommendation | Product Improvement | APPLICABLE ON MODEL: OSTF | TF | OB | SYMBOL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.0 HUMAN ENGINEERING DESIGN FACTORS** | | | | | | | | | | | | | | |
| **1.1 Anthropometric Compatability** | | | | | | | | | | | | | | |
| **1.2 Controls and Displays** | | | | | | | | | | | | | | |
| **1.3 Fail-Safe Design** | | | | | | | | | | | | | | |
| **1.4 Malfunction Detection** | | | | | | | | | | | | | | |
| **2.0 MAINTENANCE FACTORS** | | | | | | | | | | | | | | |
| **2.1 Access, Visual** | | | | | | | | | | | | | | |
| **2.2 Access, Servicing** | | | | | | | | | | | | | | |
| **2.3 Remove and Replace** | | | | | | | | | | | | | | |
| **2.4 Handling, Physical Limitations** | | | | | | | | | | | | | | |
| **2.5 Handling, Transportation** | | | | | | | | | | | | | | |
| **2.6 Vehicle Maneuverability** | | | | | | | | | | | | | | |
| **3.0 SAFETY FACTORS** | | | | | | | | | | | | | | |
| **3.1 Chemical Decontamination** | | | | | | | | | | | | | | |
| **3.2 Escape Provisions** | | | | | | | | | | | | | | |
| **3.3 Protection from Entanglement** | | | | | | | | | | | | | | |
| **3.4 Protection from Falling** | | | | | | | | | | | | | | |
| **3.5 Safety Devices (other)** | | | | | | | | | | | | | | |
| **3.6 Warning Devices** | * | * | | | | * | * | * | * | | * | * | * | |
| **4.0 PHYSIOLOGICAL FACTORS** | | | | | | | | | | | | | | |
| **4.1 Biological Damage** | | | | | | | | | | | | | | |
| **4.2 Vertigo** | | | | | | | | | | | | | | |
| **4.3 Vibration Effects** | | | | | | | | | | | | | | |
| **5.0 PSYCHOLOGICAL FACTORS** | | | | | | | | | | | | | | |
| **5.1 Fear of Heights** | | | | | | | | | | | | | | |
| **5.2 Fear of Being Crushed** | * | * | | | | * | * | * | * | | * | * | * | |
| **5.3 Fear of Falling** | | | | | | | | | | | | | | |
| **5.4 Fear of Isolation** | | | | | | | | | | | | | | |
| **5.5 Feeling of Insecurity** | | | | | | | | | | | | | | |
| **6.0 ENVIRONMENTAL FACTORS** | | | | | | | | | | | | | | |
| **6.1 Acoustic Energy (noise)** | | | | | | | | | | | | | | |
| **6.2 Humidity & Temperature** | | | | | | | | | | | | | | |
| **6.3 Illumination** | | | | | | | | | | | | | | |
| 7.0 HUMAN USE FACTORS | | | | | | | | | | | | | | |
| 7.1 Procedure | | | | | | | | | | | | | | |
| 7.2 Time Study | | | | | | | | | | | | | | |
| 7.3 Training/Selection | | | | | | | | | | | | | | |

FIGURE 24-9
SAFETY EQUIPMENT

**SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO:**
CONTAMINATION SAFEGUARDS
Preventive Procedures:

1. Selection of Chemical Materials
2. Use of Protective Equipment
3. Proper Handling of Materials

| | Human Factor Effort Required | Phase in Stage: Concept | Phase in Stage: Review | Phase in Stage: Analysis | Phase in Stage: Field Input | Human Factors Objective: Specification Complicance | Human Factors Objective: Safety | Human Factors Objective: Operational Status | Human Factors Objective: Maintenance Recommendation | Human Factors Objective: Product Improvement | Applicable on Model: OSTF | Applicable on Model: TF | Applicable on Model: OB | Symbol |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.0 HUMAN ENGINEERING DESIGN FACTORS** | | | | | | | | | | | | | | |
| **1.1 Anthropometric Compatability** | | | | | | | | | | | | | | |
| **1.2 Controls and Displays** | | | | | | | | | | | | | | |
| **1.3 Fail-Safe Design** | | | | | | | | | | | | | | |
| **1.4 Malfunction Detection** | * | | * | | | * | * | | * | | * | * | * | |
| **2.0 MAINTENANCE FACTORS** | | | | | | | | | | | | | | |
| **2.1 Access, Visual** | | | | | | | | | | | | | | |
| **2.2 Access, Servicing** | * | | * | | | * | * | | * | | * | * | * | |
| **2.3 Remove and Replace** | * | | * | | | * | * | | * | | * | * | * | |
| **2.4 Handling, Physical Limitations** | | | | | | | | | | | | | | |
| **2.5 Handling, Transportation** | | | | | | | | | | | | | | |
| **2.6 Vehicle Maneuverability** | | | | | | | | | | | | | | |
| **3.0 SAFETY FACTORS** | | | | | | | | | | | | | | |
| **3.1 Chemical Decontamination** | | | | | | | | | | | | | | |
| **3.2 Escape Provisions** | | | | | | | | | | | | | | |
| **3.3 Protection from Entanglement** | | | | | | | | | | | | | | |
| **3.4 Protection from Falling** | | | | | | | | | | | | | | |
| **3.5 Safety Devices (other)** | * | | * | | | * | * | | * | | * | * | * | |
| **3.6 Warning Devices** | * | | * | | | * | * | | * | | * | * | * | |
| **4.0 PHYSIOLOGICAL FACTORS** | | | | | | | | | | | | | | |
| **4.1 Biological Damage** | * | | * | | | * | * | | * | | * | * | * | |
| **4.2 Vertigo** | | | | | | | | | | | | | | |
| **4.3 Vibration Effects** | | | | | | | | | | | | | | |
| **5.0 PSYCHOLOGICAL FACTORS** | | | | | | | | | | | | | | |
| **5.1 Fear of Heights** | | | | | | | | | | | | | | |
| **5.2 Fear of Being Crushed** | | | | | | | | | | | | | | |
| **5.3 Fear of Falling** | | | | | | | | | | | | | | |
| **5.4 Fear of Isolation** | | | | | | | | | | | | | | |
| **5.5 Feeling of Insecurity** | * | | * | | | * | * | | * | | * | * | * | |
| **6.0 ENVIRONMENTAL FACTORS** | | | | | | | | | | | | | | |
| **6.1 Acoustic Energy (noise)** | | | | | | | | | | | | | | |
| **6.2 Humidity & Temperature** | | | | | | | | | | | | | | |
| **6.3 Illumination** | | | | | | | | | | | | | | |
| 7.0 HUMAN USE FACTORS | | | | | | | | | | | | | | |
| 7.1 Procedure | * | | * | | | * | * | | * | | * | * | * | |
| 7.2 Time Study | | | | | | | | | | | | | | |
| 7.3 Training/Selection | * | | * | | | * | * | | * | | * | * | * | |

FIGURE 24-10
SAFETY EQUIPMENT

**SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO:**
CONTAMINATION SAFEGUARDS
Protective Procedures:

Shower and Eyewash Stations

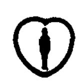
| No. | Item | Human Factor Effort Required | PHASE IN STAGE: Concept | Review | Analysis | Field Input | HUMAN FACTORS OBJECTIVE: Specification Compliance | Safety | Operational Status | Maintenance Recommendation | Product Improvement | APPLICABLE ON MODEL: OSTF | TF | OB | SYMBOL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | **HUMAN ENGINEERING DESIGN FACTORS** | | | | | | | | | | | | | |  |
| 1.1 | **Anthropometric Compatability** | * | * | | | | * | * | | | | * | * | * | |
| 1.2 | **Controls and Displays** | * | * | | | | * | * | | | | * | * | * | |
| 1.3 | **Fail-Safe Design** | | | | | | | | | | | | | | |
| 1.4 | **Malfunction Detection** | | | | | | | | | | | | | | |
| 2.0 | **MAINTENANCE FACTORS** | | | | | | | | | | | | | |  |
| 2.1 | **Access, Visual** | | | | | | | | | | | | | | |
| 2.2 | **Access, Servicing** | | | | | | | | | | | | | | |
| 2.3 | **Remove and Replace** | | | | | | | | | | | | | | |
| 2.4 | **Handling, Physical Limitations** | | | | | | | | | | | | | | |
| 2.5 | **Handling, Transportation** | | | | | | | | | | | | | | |
| 2.6 | **Vehicle Maneuverability** | | | | | | | | | | | | | | |
| 3.0 | **SAFETY FACTORS** | | | | | | | | | | | | | |  |
| 3.1 | **Chemical Decontamination** | * | * | | | | * | * | | | | * | * | * | |
| 3.2 | **Escape Provisions** | | | | | | | | | | | | | | |
| 3.3 | **Protection from Entanglement** | | | | | | | | | | | | | | |
| 3.4 | **Protection from Falling** | | | | | | | | | | | | | | |
| 3.5 | **Safety Devices (other)** | | | | | | | | | | | | | | |
| 3.6 | **Warning Devices** | | | | | | | | | | | | | | |
| 4.0 | **PHYSIOLOGICAL FACTORS** | | | | | | | | | | | | | |  |
| 4.1 | **Biological Damage** | * | * | | | | * | * | | | | * | * | * | |
| 4.2 | **Vertigo** | | | | | | | | | | | | | | |
| 4.3 | **Vibration Effects** | | | | | | | | | | | | | | |
| 5.0 | **PSYCHOLOGICAL FACTORS** | | | | | | | | | | | | | |  |
| 5.1 | **Fear of Heights** | | | | | | | | | | | | | | |
| 5.2 | **Fear of Being Crushed** | | | | | | | | | | | | | | |
| 5.3 | **Fear of Falling** | | | | | | | | | | | | | | |
| 5.4 | **Fear of Isolation** | | | | | | | | | | | | | | |
| 5.5 | **Feeling of Insecurity** | * | * | | | | | * | | | | * | * | * | |
| 6.0 | **ENVIRONMENTAL FACTORS** | | | | | | | | | | | | | |  |
| 6.1 | **Acoustic Energy (noise)** | | | | | | | | | | | | | | |
| 6.2 | **Humidity & Temperature** | | | | | | | | | | | | | | |
| 6.3 | **Illumination** | | | | | | | | | | | | | | |
| 7.0 | **HUMAN USE FACTORS** | | | | | | | | | | | | | |  |
| 7.1 | **Procedure** | | | | | | | | | | | | | | |
| 7.2 | **Time Study** | | | | | | | | | | | | | | |
| 7.3 | **Training/Selection** | | | | | | | | | | | | | | |

FIGURE 24-11
SAFETY EQUIPMENT

**SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO:**
SAFEGUARDS AGAINST HUMAN INITIATED FAILURES:

1. Color Coding of Manual Valves
2. Periodic Revision of Maintenance Procedures
3. Establishment of Installation Procedures

| No. | Item | Human Factor Effort Required | Concept (Phase in Stage) | Review (Phase in Stage) | Analysis (Phase in Stage) | Field Input (Phase in Stage) | Specification Compliance (Human Factors Objective) | Safety (Human Factors Objective) | Operational Status (Human Factors Objective) | Maintenance Recommendation (Human Factors Objective) | Product Improvement (Human Factors Objective) | OSTF (Applicable on Model) | TF (Applicable on Model) | OB (Applicable on Model) | Symbol |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | **HUMAN ENGINEERING DESIGN FACTORS** | | | | | | | | | | | | | |  |
| 1.1 | **Anthropometric Compatability** | * | | * | | * | * | * | * | * | * | | * | * | |
| 1.2 | **Controls and Displays** | * | | * | | * | * | * | * | * | * | | * | * | |
| 1.3 | **Fail-Safe Design** | * | | * | | * | * | * | * | * | * | | * | * | |
| 1.4 | **Malfunction Detection** | * | | * | | * | * | * | * | * | * | | * | * | |
| 2.0 | **MAINTENANCE FACTORS** | | | | | | | | | | | | | |  |
| 2.1 | **Access, Visual** | * | | * | | * | * | * | * | * | * | | * | * | |
| 2.2 | **Access, Servicing** | * | | * | | * | * | * | * | * | * | | * | * | |
| 2.3 | **Remove and Replace** | * | | * | | * | * | * | * | * | * | | * | * | |
| 2.4 | **Handling, Physical Limitations** | | | | | | | | | | | | | | |
| 2.5 | **Handling, Transportation** | | | | | | | | | | | | | | |
| 2.6 | **Vehicle Maneuverability** | | | | | | | | | | | | | | |
| 3.0 | **SAFETY FACTORS** | | | | | | | | | | | | | |  |
| 3.1 | **Chemical Decontamination** | | | | | | | | | | | | | | |
| 3.2 | **Escape Provisions** | | | | | | | | | | | | | | |
| 3.3 | **Protection from Entanglement** | | | | | | | | | | | | | | |
| 3.4 | **Protection from Falling** | | | | | | | | | | | | | | |
| 3.5 | **Safety Devices (other)** | | | | | | | | | | | | | | |
| 3.6 | **Warning Devices** | * | | * | | * | * | * | * | * | * | | * | * | |
| 4.0 | **PHYSIOLOGICAL FACTORS** | | | | | | | | | | | | | |  |
| 4.1 | **Biological Damage** | | | | | | | | | | | | | | |
| 4.2 | **Vertigo** | | | | | | | | | | | | | | |
| 4.3 | **Vibration Effects** | | | | | | | | | | | | | | |
| 5.0 | **PSYCHOLOGICAL FACTORS** | | | | | | | | | | | | | |  |
| 5.1 | **Fear of Heights** | | | | | | | | | | | | | | |
| 5.2 | **Fear of Being Crushed** | | | | | | | | | | | | | | |
| 5.3 | **Fear of Falling** | | | | | | | | | | | | | | |
| 5.4 | **Fear of Isolation** | | | | | | | | | | | | | | |
| 5.5 | **Feeling of Insecurity** | * | | * | | * | * | * | * | * | * | | * | * | |
| 6.0 | **ENVIRONMENTAL FACTORS** | | | | | | | | | | | | | |  |
| 6.1 | **Acoustic Energy (noise)** | | | | | | | | | | | | | | |
| 6.2 | **Humidity & Temperature** | | | | | | | | | | | | | | |
| 6.3 | **Illumination** | | | | | | | | | | | | | | |
| 7.0 | HUMAN USE FACTORS | | | | | | | | | | | | | |  |
| 7.1 | **Procedure** | * | | * | | * | * | * | * | * | * | | * | * | |
| 7.2 | **Time Study** | | | | | | | | | | | | | | |
| 7.3 | **Training/Selection** | * | | * | | * | * | * | * | * | * | | * | * | |

FIGURE 24-12
SAFETY EQUIPMENT

1.0 DESCRIPTION

1.1.0 The safety equipment presented herein covers only those safety features which have not been treated in previous chapters. These items include:

a. personnel access ways, such as the personnel stairway, and the bottom access stairway,

b. personnel safeguards, such as the emergency ladder, guard rails, safety nets, safety gates and audible warning devices,

c. contamination safeguards, such as protective procedures and equipment to prevent contamination, and decontamination equipment such as the eyewash and shower station for use in case of chemical contamination,

d. safeguards against human initiated failures, such as the coding of manually operated valves and the periodic revision of maintenance procedures.

1.1.1 Personnel Accessways

a. Personnel Stairway

The personnel stairway is mounted on the crib structure between elevation 307'-5$\frac{1}{4}$" and 379'-0", and is attached to the outer face "D" in Quadrant IV. This stairway is used at the Training Facility to provide an additional means for personnel to move from one work platform to another. This is necessary because of the increased traffic demands characteristic of a training base. (Ref. 5 & 6).

b. Bottom Access Stairway

As a result of AMF's Facility Access Studies (Ref. 3 & 4) which revealed that there was no means of obtaining easy access from the

bottom of the crib to the lower 14½ feet of the silo and grating, an additional stairway and platform was added from Elevator Stop No. 8 at Elevation 269'-10" down to the grating of the Silo, at Elevation 255'-4".

### 1.1.2 Personnel Safeguards

#### a. Emergency Ladders

An emergency ladder is required to permit personnel to evacuate the Silo in case of emergency without depending on the elevator or personnel stairway (Ref. 12). All fixed ladders of 20 feet or more in height require the additional protection of a cage guard. This enclosure is fastened to the side rails so that it encloses the climbing space of the ladder for the safety of the person who must climb the ladder (Ref. 10). This cage serves to protect personnel from accidental falling, since its narrow size will tend to brace a man who slips, and it also serves to deflect possible falling objects, so that they will not strike personnel using the emergency ladder. Also, the cage protects personnel from swinging hoists or other heavy moving equipment which could possibly swing into an unprotected area. Since the emergency ladder represents a straight drop of over 100 feet and The American Standard Safety Code (Ref. 7 and 11) requires either landing platforms at every 30 feet of height or the use of carrier rails with safety belts, this installation employs the additional safeguard of a carrier (guide) rail which has been attached to the centerline of the rungs. A safety sleeve, which travels along the rail, is attached to the safety belt (Ref. 9).

In normal operation, the safety sleeve is spring loaded to keep the latching device away from the rail, thus permitting personnel to climb up or down the ladder. If, however, anything disabling should occur while one is on the ladder, the weight of the body would override the spring and force the latch into the nearest locking slot of the guide rail (Ref. 8). This device provides valuable protection in several ways. It limits a person's fall to 6 inches if one slips off a rung or is overcome by toxic fumes. In case a person were injured but not rendered unconscious, he could pull himself up the escape ladder by hand, by using the locking characteristic to climb upward. The inclusion of the guide rail and safety sleeve virtually provides personnel with one extra hand. In the worst conceivable circumstance, if a man lost the use of as much as one hand and two feet, nevertheless with the use of only one good hand and the guide rail, he would still be able to pull himself up to the top of the emergency ladder.

b. Safety Nets

At the top of the Silo on the catwalk at 389'-0", Face D, an overhanging structure with safety net was added in order to provide personnel with safe access around the hydraulic manifold, (Ref. 13), as authorized by Preliminary Engineering Inspection RFA #12.

c. Guard Rails

On those occasions when there is no missile in the silo, guard rails are needed adjacent to the missile area along the inner edges of the work platforms, to protect personnel from falling into the open pit (Ref. 15, 16, 17, and 18).

d. Safety Gates

Safety gates are provided at all personnel elevator stops in order to prevent personnel from falling into an open shaft, and to protect them from possible injury which could be caused by moving parts in the elevator travel space (Ref. 1 and 2).

e. Audible Warning Devices

Operation of the main closure doors from the local control station automatically actuates a warning klaxon horn, which sounds continuously throughout the operation of the doors. As an additional safeguard, the audible warning device sounds for 30 seconds before the doors begin to move (Ref. 1).

1.1.3 Contamination Safeguards

Contamination safeguards exist in 2 areas:

(1) in preventive measures, such as cautious selection of chemical materials, use of protective equipment and the proper handling of materials in order to prevent contamination (Ref. 24),

(2) and in protective measures, such as the provision of procedures and equipment to be used in order to achieve decontamination in case the preventive measures fail.

a. Selection of Materials: Preventive Safeguards

In order to minimize chemical contamination of personnel, or biological damage from fumes, burns or explosions, great care should be taken in the selection of chemical materials for use in the Silo (Ref. 23).

The most fundamental consideration is the selection of all materials, whether to be used in fabrication or maintenance, on the basis of their compatibility with liquid oxygen (Ref. 21 & 22).

This oxidizer is a very hazardous fluid and is especially incompatible with the hydrocarbons, such as acetylene or grease and dirt, even in minute particle quantitites. Carbon tetrachloride is another highly toxic fluid which should be avoided for cleaning. Other fluids are equally useful and have the added advantage of being safe for area personnel (Ref. 20, and 19). One other practice which applies universally to the Silo is lubrication. Extreme care should be taken to select and recommend halocarbons for lubricants instead of hydrocarbons .

Another real and insidious hazard is the damage which results from the undetected presence of gaseous nitrogen. If nitrogen escapes from nitrogen lines, being heavier than oxygen, it settles at the bottom of the Silo. If large volumes of nitrogen are permitted to accumulate, personnel who are working in the area and unaware of the presence of this odorless gas or conversely, of the absence of necessary alveolar oxygen, will become asphyxiated and unable even to summon help. To protect personnel from this possibility, either adequate ventilation must be provided at the bottom of the Silo or some visual/auditory means of warning personnel of hazardous levels of toxic fumes must be provided (Ref. 22).

b. Handling of Hazardous Materials: Preventive Safeguards

Hasardous materials such as liquid oxygen, other cryogenic chemicals, or toxic paints and cleaning agents, should be handled only by personnel who are properly equipped with protective clothing and devices. They should always adhere to the prescribed procedures for the safe handling of hazardous materials (Ref. 22).

In addition, in all areas where liquid oxygen compatibility is required, the floors and decks should be provided with non-sparking surfaces, in order to prevent the hazards of fire or explosion (Ref. 21).

Scrupulous cleanliness also is of prime importance. Even microscopic particles of welding materials or hydrocarbonaceous material, such as the ubiquitous granules of grease and dirt, are subject to spontaneous combustion, if liquid oxygen comes in contact with them. It is imperative that a clean environment be maintained, and that personnel be protected from accidental oxidation, an ever present danger in a liquid oxygen environment.

c. Shower and Eyewash Station: Protective Safeguard

The Shower and Eyewash Stations, of which there are a total of 6, are located one at each of the five work platforms, and one at the top of the launcher platform. The shower is activated by pulling an oversized ring on a chain and the eyewash spray is operated by hand. With this type of control, the shower and eyewash should be easy to operate simultaneously under emergency conditions (Ref. 25, 26, 27, 28, 29 and 30).

### 1.1.4 Safeguards Against Human Initiated Failures

It is most desirable to prevent or at the least to minimize human initiated failures in any weapon system. Considerable attention has been given to this effort on the Titan Launcher System under other related chapters (i.e. No. 19 Logic System and Test Equipment, No. 20 Tunnel Entrance Control Station) where extensive investigation of human failure situations was performed and reported. However, some areas which have not been covered elsewhere and fall within the category of product improvement are mentioned below:

a. Color Coding Manual Valves

At present, there is no way of visually ascertaining the proper operating position of the near hundred manually operated valves in the Titan Launcher System, nor of determining visually if the valves are set at the proper position (Ref. 31). A greatly needed improvement would be the color coding of each valve to indicate the normal operating position: black handles for normally closed valves, yellow handles for normally open valves, and white markers on the handle at the 12 o'clock position when the valve is properly set.

b. Revision of Maintenance Procedures

Although maintenance procedures were established as hardware systems have been developed, changes in hardware design mean that maintenance procedures must be revised and coordinated at an equal pace. However, since these revisions are established in the field, there has been no opportunity to evaluate the

revised procedures from the human factors point-of-view. In order to assure that the best human factors applications are perpetuated on the titan Launcher System, all field revisions should be reviewed by the Human Factors team (Ref. 32).

## 1.2 Applicable Human Factors Considerations

Men of the Air Force population who represent body sizes between the 5th and 95th percentile must be able to operate efficiently within the confines of the missile silo without causing damage to equipment or injury to themselves or to other personnel. The areas to be frequented by personnel must provide adequate protection in the way of design, markings, warnings, and supplementary devices if they are required (Ref. 1 and 2). Factors contributing to safe and successful operation by personnel have been itemized on the summary checklists, Figures 24-4, 24-5, 24-6, 24-7, 24-8, 24-9, 24-10, 24-11 and 24-12.

## 2.0 SYNOPSIS

The synopsis shee‘‘s have been deleted from this chapter because each item of safety equ  ment has already been adequately treated in previous chapters, in Human Factors drawings and in AMF drawings. The complete list of drawings, by subject, are included in Section 4.0 References.

## 3.0 DISCUSSION

Safety equipment, as such, should instill confidence in the user and provide for any possible eventuality.

### 3.1 Carrier Rail Safety Sleeves

After the carrier rail was installed, it was suggested by the Human Factors team that the carrier rail should have a break at each work level, as a product improvement. This break would have allowed an individual to switch in and out at each level as needed if the safety sleeve were permanently attached to his safety belt (Ref. 3).

As the system exists now, there are good possibilities that all of the safety sleeves will be found piled up at the top of the ladder. After use, as each successive safety sleeve is left at the top of the rail, the lowest sleeve will be positioned so far below the minimum space required for proper departure, that personnel will be forced to disconnect their safety belts from the safety sleeve while they are perched in their most vulnerable position. Another undesirable possibility exists. Personnel traveling up the ladder during an emergency would be forced to uncouple and couple each successive safety sleeve upon contact as he traveled upward, unless he were able to push them upward ahead of him.

Inevitably, it will be found that as long as the safety sleeves are not attached permanently to the safety belts, they will always be found bunched together at one location, and never at the right level when needed.

## 3.2 Safety Nets

Whereas the presence of a safety net may encourage a feeling of confidence in personnel working in the upper silo levels, it would be preferable if additional safeguards could be provided. It would be better if falling could be prevented. In the area of the hydraulic manifold at the upper catwalk level, it is virtually impossible for personnel to move around the manifold. A simple yet very effective safeguard is the addition of safety belt hooks at appropriate locations which would permit personnel to attach a safety belt while working or walking in the manifold area. It is recommended that these appropriate locations be "field-designated" at the actual installation.

## 3.3 Eye Wash and Shower Stations

It is necessary to install Eyewash and Shower Stations at identical locations on each work level so that when they are needed, contaminated personnel will be uniformly oriented wherever they are and need not be confused or delayed by differences in locations.

## 4.0 REFERENCES

### GENERAL


1. AFBM Exhibit 57-8A, Human Engineering Design Standards for Missile Equipment, 1 November 1958.

2. ADS-1003C, Design Specification for Personnel Safety for WS 107A-2 Launcher System, American Machine & Foundry Company, Greenwich Engineering Division, Revised 29 June, 1959.


### PERSONNEL ACCESSWAYS

a. Personnel Stairway and Bottom Access Stairway


3. AMF Report ER-TPS-250, WS 107A-2 Launcher System Facility Maintenance Access Study OSTF, 12/30/59.

4. AMF Report ER-TPS-257, WS 107A-2 Launcher System Facility Maintenance Access Study Training Facility-1, 1/15/60.

5. AMF Drawing No. HF-T-1056 (4 Sheets) Personnel Stairway Layout OSTF-TB.

6. AMF Drawing No. SK 194-10602 - Crib Stairway Study.


### PERSONNEL SAFEGUARDS

a. Emergency Ladders


7. ASA-A14.3-1956, American Safety Code for Fixed Ladders.

8. Safety Tower Ladder Company, Inc., New York, New York, Catalog and Safety Device Specifications.

9. AMF Document, TS 7.2.24, DDL Review - SK-194-20757 - Emergency Ladder Face D, 9/9/59.

10. Vendor Drawing No. JL-981-1-C, Cage Ladder, Aluminum Ladder Co., Worthington, Pa.

11. AMF Drawing No. HF-T-1085 - Access Ladder OSTF & Up.

12. AMF Drawing No. SK 194-90544 - Platform Bridge to Emergency Ladder.

b. Safety Nets

13. Technical Directive, Space Technology Laboratories, Inc., P. O. 95001, Los Angeles, California, Launcher Design Changes, 12/29/58.

14. AMF Drawing No. HF-T-1061 - Stage I Engine Access Safety Net Study.

c. Guard Rails

15. AMF Document, CR VB-0095, 10/6/60.

16. AMF Drawing No. HF-T-1067 - Catwalk Stairway to Bridge, OSTF - TB.

17. AMF Drawing No. HF-T-1104 - Bridge & Catwalk Guard Rail Modifications, OSTF & TF-1.

18. AMF Drawing No. HF-T-1138 - Catwalk and Bridge Handrail Study.

CONTAMINATION SAFEGUARDS, PREVENTIVE PROCEDURES

Selection and Chemical Handling of Hazardous Materials

19. Article, Don't Use Carbon Tet, Modern Sanitation and Building Maintenance, March, 1959.

20. AMF Report, ER-TPS-143, Carbon Tetrachloride As A Cleaning Agent (Personnel Safety), 11/14/58.

21. AMF Report, ER-TPS-166, Preliminary Lox Spillage Analysis, 1/8/59.

22. AMF Report, ER-TPS-184, Toxicity Analysis in the Silo, 2/24/59.

23. AMF Report, FTR-TPS-156, Spark Ignition Tests of Ucon Hydraulic Fluids, 3/23/59.

24. AMF Report, FTR-TPS-82, Corrosion and Other Environmental Effects of Equipment Components at Canaveral, 8/25/58.

CONTAMINATION SAFEGUARDS, PROTECTIVE PROCEDURES

Shower & Eye Wash Station

25. AMF Document (AF 04(647)-138), Preliminary Design Specification Emergency Shower and Eye-Wash Station for WS 107A-2 Launcher System, 2/16/59.

26. AMF (AF 04(647)-138), Design Specification for Emergency Shower and Eye Wash Station.

27. ADS-1073, Emergency Shower and Eye-Wash Station, 7/3/59.

28. AMF Report, ER-TPS-150A, Addendum to ER-TPS-150A, Effects on Launcher Design Due to Lowered Silo Temperature, 1/15/59.

29. AMF Report, MR #1125, Titan Emergency Shower & Eyewash, 3/24/59.

30. AMF Drawing No. HF-T-1111 (6 Sheets) Emergency Shower & Eye Wash Location Study.

## SAFEGUARDS AGAINST HUMAN INITIATED FAILURES

31. AMF Report, ER-TS 7.1.15, Coding of Valves for the Titan Launcher System, 9/5/61.

32. AMF Report, ER-TS 7.1.39, Human-Initiated Failures at the Titan TF and OB Silos, 10/9/61.

Chapter 25

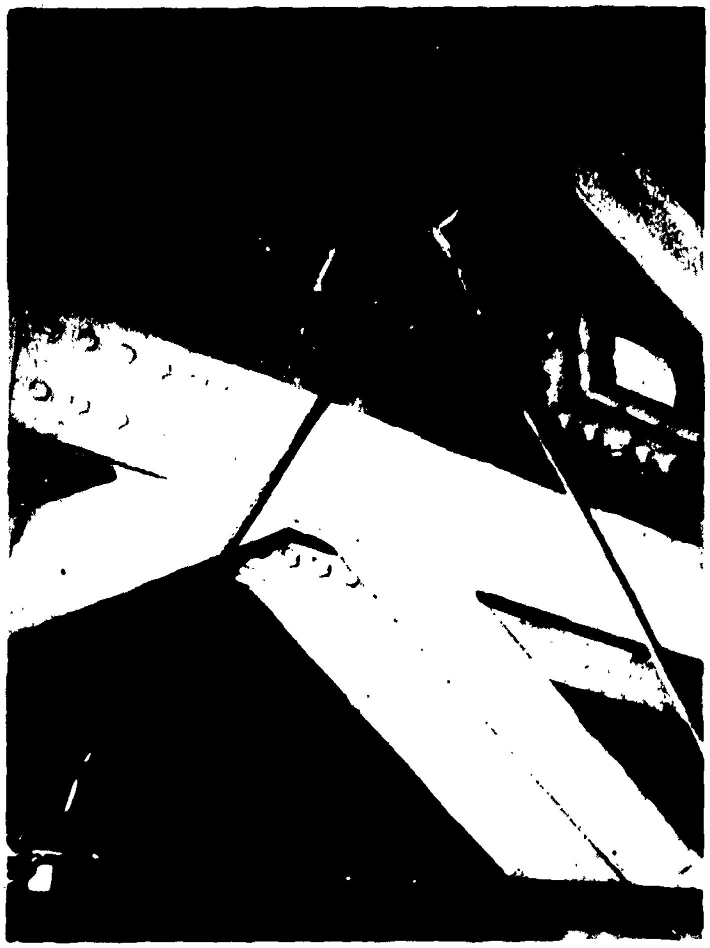
# Human Factors Review and Evaluation of the Utilities

DOWN TIME

Adequate access for maintenance is essential to minimize down time and to keep the Launcher System in a ready state for the fulfillment of its mission.

SAFETY HOOKS

Safety hooks (for safety belt attachment) have been recommended in those areas where ladders and catwalks have been considered superfluous due to an expected low frequency of maintenance access requirements.



ACCESS

All utility junction boxes, connection boxes, valves and manifolds must be accessible to Air Force maintenance crews.

PLATFORMS

Extensive platform arrangements were studied and recommended to improve access throughout the Launcher Silo.

HANDLING

Eye hooks have been recommended for all manifolds and junction boxes over 35 lbs. so that hoisting devices can be easily attached.

FIGURE 25-1
HUMAN FACTORS INPUTS
UTILITIES

**SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO:**
UTILITIES

| | | Human Factor Effort Required | PHASE II STAGE: Concept | Review | Analysis | Field Input | HUMAN FACTORS OBJECTIVE: Specification Compliance | Safety | Operational Status | Maintenance Recommendation | Product Improvement | APPLICABLE ON MODEL: OSTF | TF | OB | SYMBOL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | HUMAN ENGINEERING DESIGN FACTORS | | | | | | | | | | | | | | |
| 1.1 | Anthropometric Compatability | * | * | * | * | * | * | * | | * | | * | * | * | |
| 1.2 | Controls and Displays | | | | | | | | | | | | | | |
| 1.3 | Fail-Safe Design | | | | | | | | | | | | | | |
| 1.4 | Malfunction Detection | * | * | * | * | | | * | | * | | * | * | * | |
| 2.0 | MAINTENANCE FACTORS | | | | | | | | | | | | | | |
| 2.1 | Access, Visual | * | * | * | * | | | | | | | * | * | * | |
| 2.2 | Access, Servicing | * | * | * | * | | | * | | * | * | * | * | * | |
| 2.3 | Remove and Replace | * | * | * | * | | | * | | * | * | * | * | * | |
| 2.4 | Handling, Physical Limitations | * | * | * | * | | * | * | | | | * | * | * | |
| 2.5 | Handling, Transportation | | | | | | | | | | | | | | |
| 2.6 | Vehicle Maneuverability | | | | | | | | | | | | | | |
| 3.0 | SAFETY FACTORS | | | | | | | | | | | | | | |
| 3.1 | Chemical Decontamination | | | | | | | | | | | | | | |
| 3.2 | Escape Provisions | | | | | | | | | | | | | | |
| 3.3 | Protection from Entanglement | | | | | | | | | | | | | | |
| 3.4 | Protection from Falling | * | * | * | * | * | | * | | | | * | * | * | |
| 3.5 | Safety Devices (other) | * | * | * | * | * | | * | | | | * | * | * | |
| 3.6 | Warning Devices | | | | | | | | | | | | | | |
| 4.0 | PHYSIOLOGICAL FACTORS | | | | | | | | | | | | | | |
| 4.1 | Biological Damage | | | | | | | | | | | | | | |
| 4.2 | Vertigo | | | | | | | | | | | | | | |
| 4.3 | Vibration Effects | | | | | | | | | | | | | | |
| 5.0 | PSYCHOLOGICAL FACTORS | | | | | | | | | | | | | | |
| 5.1 | Fear of Heights | | | | | | | | | | | | | | |
| 5.2 | Fear of Being Crushed | | | | | | | | | | | | | | |
| 5.3 | Fear of Falling | * | * | * | * | | | * | | * | * | * | * | * | |
| 5.4 | Fear of Isolation | | | | | | | | | | | | | | |
| 5.5 | Feeling of Insecurity | | | | | | | | | | | | | | |
| 6.0 | ENVIRONMENTAL FACTORS | | | | | | | | | | | | | | |
| 6.1 | Acoustic Energy (noise) | | | | | | | | | | | | | | |
| 6.2 | Humidity & Temperature | | | | | | | | | | | | | | |
| 6.3 | Illumination | * | | | | | * | * | | * | * | * | * | * | |
| 7.0 | HUMAN USE FACTORS | | | | | | | | | | | | | | |
| 7.1 | Procedure | * | * | | * | * | | | | | | * | * | * | |
| 7.2 | Time Study | | | | | | | | | | | | | | |
| 7.3 | Training/Selection | | | | | | | | | | | | | | |

FIGURE 25-2

## 1.0 DESCRIPTION

1.1 The utilities consist of the hydraulic and water piping with their associated valves (manual and automatic) manifolds, cylinders, snubbers, and all electrical conduit connected to junction boxes, key switches, limit switches, push button stations, utility outlets, etc. This supporting control equipment is located at various elevations throughout the crib and launcher structure and in a few instances on the silo wall.

1.2 Men of the Air Force population who represent body sizes between the 5th and 95th percentile must be able to remove, replace or service efficiently all utility components that may require attention. The operations or methods used should not cause injury to personnel or damage to equipment. Factors contributing to the successful servicing of the utilities have been itemized on the summary checklist (Fig. 25-2) and the progress of this design effort has been tabulated in the following synopsis.

ITEM: UTILITIES (HYDRAULIC & ELECTRIC)

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: CONTRACTUAL AFBM 57-8A | DOCUMENTARY COMPLIANCE: TECH. REF. | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION: ANAL | VERIFICATION: EQUIP | VERIFICATION: TEST | RESULTS. | RELATIVE VALUE % |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1.0 HUMAN ENGINEERING DESIGN FACTORS<br>1.1 ANTHROPOMETRIC COMPATABILITY | 6.1.1 | | LOCATION OF EQUIPMENT SUITABLE FOR 95% OF THE AIR FORCE POPULATION. MAXIMUM ALLOWABLE OVERHEAD REACH - 76 INCHES. MAXIMUM ALLOWABLE DEPTH OF REACH - 23 INCHES. | HR-V-159<br>REACH ENVELOPES<br>HF-F-1004, 1005, 1006, 1007, 1008, 1009, 1010, & 1011 | RECOMMENDED LOCATING EQUIPMENT FOR ACCESSIBILITY AT TIME OF MOCKUP PROGRAM PER REACH ENVELOPE DRAWINGS. | X | | | 146 DIRECTLY ACCESS-IBLE (WITHOUT SUPPLEMENTARY ACCESS MEANS). | [illegible] |
| 2.0 MAINTENANCE FACTORS<br>2.1 ACCESS, VISUAL | 4.3.3.9.1.10 TO 4.3.3.9.1.10.4, & 2.1.4 | [illegible]-2003C | MEANS FOR VISUAL ACCESS SHOULD BE PROVIDED. | HR-V-159<br>HR-GTS-173<br>DRAWINGS SHOWING REACH ENVELOPES TO 59-4021 | RECOMMENDED A STUDY OF ACCESSIBILITY, TO ITEMS REQUIRING SCAFFOLDING OR STANDS FOR POSITIVE PROCEDURE. | X | | | MAY BE PERFORMED UNDER CATEGORY II TESTS. | [illegible] |
| 2.2 ACCESS, SERVICING | 4.3.2.3, 4.3.2.8, 4.3.3.1, 4.3.3.6.1, 4.3.3.6.8, 4.3.3.7.1, 4.3.3.8.2, & 4.3.3.9.1.9 | [illegible]-2003C | ACCESS FOR SERVICING MUST BE PROVIDED TO MINIMIZE DOWN TIME. USE OF SPECIAL PORTABLE EQUIPMENT SHOULD BE KEPT TO A MINIMUM. | HR-V-159, HR-GTS-223, HR-GTS-173, TD 59-4021, SK194-10761, HR-GTS-111, SK-194-10815, TD-407-39, HR-GTS-231, HR-GTS-218 | RECOMMENDED RELOCATION OF INACCESSIBLE MANIFOLDS (TOTAL 18). RECOMMENDED METHODS OF ACCESS. PERSONNEL ENVELOPE CRIB TO SILO MOUNTED PLATFORMS. | X | | | PARTIALLY ACCEPTED. | [illegible] |
| 2.3 REMOVE & REPLACE | 4.2.1, 4.2.2, 4.3.2.1, 4.3.2.2, 4.3.3.3, 4.3.3.5, 4.3.3.8.1, 4.3.3.9.1.4, 4.3.3.9.1.8 & 4.3.3.9.2 - 4.3.3.9.4 | | MUST BE SAFELY ACCESSIBLE IN ORDER TO REPLACE. | HR-GTS-173<br>HR-GTS-223 | IT WAS RECOMMENDED THAT THE MANIFOLDS BE RELOCATED AS STATED FOR OSTF, TF & OB IN ORDER TO ELIMINATE THE DIFFICULTIES INVOLVED IN EXTENSIVE USE OF LADDERS AND MOBILE WORK PLATFORMS. | X | | | PARTIALLY ADOPTED. | [illegible] |

2.0 SYNOPSIS

ITEM: UTILITIES (HYDRAULIC & ELECTRIC)

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE | | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA | | VERIFICATION | | | RESULTS | % RELATIVE VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| | CONTRACTUAL AFBM 57-8A | TECH. REF. | | PARTICIPATION | RECOMMENDATIONS | ANAL | EQUIP | TEST | | |
| 2.4 HANDLING, PHYSICAL LIMITATIONS | 4.3.3.1 | | THE WEIGHT OF A REMOVABLE UNIT TO BE HANDLED BY PERSONNEL SHALL NOT EXCEED 35 LBS. | | IF A MANIFOLD EXCEEDS 35 LBS. - THE HOOKS ATTACHED TO THE FRAME SHOULD BE USED TO HANDLE THE UNIT. | | | | PARTIALLY ADOPTED | 10 |
| 3.0 SAFETY FACTORS<br>3.4 PROTECTION FROM FALLING | 7.5, 7.8, 7.9 | ARD-3003C | RAMP ON CATWALK AROUND MANIFOLD B IN FACE D (WITH SAFETY NET ATTACHED). | SK196-90965 | RECOMMEND THE PLACING OF SAFETY HOOKS IN AREAS CONSIDERED TO BE MARGINAL OR BEYOND; THIS SHOULD BE DONE BY A QUALIFIED HUMAN FACTORS ENGINEER FAMILIAR WITH TITAN. | X | | | PARTIALLY ADOPTED | 20 |
| 3.5 SAFETY DEVICES | 7.6, 7.7, 7.11, 7.15, 7.19, AND 7.22 | ARD-30070 3.2.7.2, 3.3 AND 3.5 | SAFETY BELT. | | | | | | | |
| 5.0 PSYCHOLOGICAL FACTORS<br>5.3 FEAR OF FALLING | 7.5, 7.8, & 7.9 | ARD-30030C | ALL UTILITIES MUST BE ACCESSIBLE WITHOUT THE DANGER OF FALLING. | SEE REFERENCE SECTION NUMBERS 1 THRU 46 FOR DRAWINGS MADE IN PARTICIPATION. | RECOMMENDED PLATFORMS THROUGHOUT THE SILO FOR COMPLETE COVERAGE OF EQUIPMENT ACCESS. | X | | | NOT ADOPTED | 10 |
| 6.0 ENVIRONMENTAL FACTORS<br>6.3 ILLUMINATION | 5.5, 5.5.1, 5.5.2, 5.5.3 7.2.1 AND TABLE 3. | | WORK AREAS SHOULD BE ILLUMINATED BY 25 TO 100 FOOT CANDLES. | | ENC PRESENTLY STUDYING LIGHTING CONDITIONS. | | | | NOT AVAILABLE. | |
| 7.0 HUMAN USE FACTORS<br>7.1 PROCEDURES | | | HUMAN FACTORS ENGINEER FAMILIAR WITH THE LAUNCHER SYSTEM AND THE ONE AVAILABLE MUST OBTAIN TOUCH ACCESS IF NOT ABLE TO REACH EQUIPMENT THEN DETAILED REPORT ON METHOD TO BE USED MUST BE SUBMITTED WITH EACH PROBLEM AREA. | HA-2/S-5013 | RECOMMEND IMPROVING ACCESS TO UTILITIES SO THAT MISSILE SILO WILL NOT BE TIED UP FOR EXTENDED PERIODS OF TIME DUE TO SPECIAL ACCESS REQUIREMENTS. | X | | | PARTIALLY ADOPTED | 10 |
| | | | | | | | | | | 100 |

2.0 SYNOPSIS

3.0 DISCUSSION

3.1 The utilities have not been placed in the most accessible areas due to over-riding considerations of design and delivery. Approximately 46% are directly accessible, 17% require use of the mobile work platform, accessory work stand, or a ladder, and the balance can be made accessible using rigging techniques. Human Factors recommends placing safety hooks in areas considered marginal or below with respect to access. There are areas throughout the silo and crib that contain only a few components. Installation of an elaborate access approach is not warranted if relatively safe access can be provided by installing field located safety hooks to be used by personnel wearing safety belts. These areas should be determined by a qualified Human Factors engineer familiar with Titan. Many areas need additional light for safe working conditions because the buildup of equipment has blocked or reduced existing light sources.

3.2 During the original concept stages Human Factors had proposed many platforms and other methods of access most of which were not accepted because of austere design and schedule requirements. After removal of all installation scaffolding, the need for additional access became evident.

## 4.0 BASIC REFERENCES


1. AFBM 57-8A, Human Engineering Design Standards for Missile System Equipment.
2. AFBM Technical Directive 59-4021 - Maintenance Access in the Missile Silo.
3. AMF Design Specification 1003C, Personnel Safety for WS 107A-2 Launcher System.
4. AMF Design Specification 1078, Facility Access Platforms for WS 107A-2 Launcher System.
5. AMF Procedure Specification 1070A, Formation and Application of a Reference Designation System for Hydraulic and Water Utility Lines and Components Within the WS 107A-2 Launcher System.
6. AMF Report, ER-TPS-223 - Access for Maintenance-Manifolds Crib Mounted.
7. AMF Report, ER-TPS-231 - Access for Maintenance Junction Boxes.
8. AMF Report, ER-TPS-192 - OSTF Door Foundation Interference (Utilities, Hyd.).
9. AMF Report, ER-T/S-5103 - Human Factors Field Test Access VAFB.
10. AMF Report, MR-TPS-111 - In Silo Maintenance Study.

## 4.1 DRAWING REFERENCES

1. AMF Drawing No. HF-T-1000 - Access Ladders.

2. AMF Drawing No. HF-T-1003 - Test Plug Connections and Disconnections.

3. AMF Drawing No. HF-T-1004 - Basic Data Access Areas via Hand Reach, Ladder & Mobile Platform.

4. AMF Drawing No. HF-T-1005 - Utilities Access Area - (Ref. Data).

5. AMF Drawing No. HF-T-1006 - Access Area Bay 1.

6. AMF Drawing No. HF-T-1007 - Access Area Bay 2.

7. AMF Drawing No. HF-T-1008 - Access Area Bay 3.

8. AMF Drawing No. HF-T-1009 - Access Area Bay 4.

9. AMF Drawing No. HF-T-1010 - Access Area Bay 5 & 6.

10. AMF Drawing No. HF-T-1011 - Access Area Bay 7 & 8.

11. AMF Drawing No. HF-T-1035 - Test Plug Pin Connection Schematic.

12. AMF Drawing No. HF-T-1036 - Platform, Top Crib Access Face A.

13. AMF Drawing No. HF-T-1037 - Access - Top of Silo (Quad. IV) TF & OB.

14. AMF Drawing No. HF-T-1043 - Proposed Modifications - Face "A" Bay 3 (Personnel Envelope).

15. AMF Drawing No. HF-T-1044 - Access Ladder Cold Helium Line Valves @ 378'-4" Quad. II.

16. AMF Drawing No. HF-T-1045 - Study Valve Access Quad. II, Face A Between #1 & #2 Work Platform.

17. AMF Drawing No. HF-T-1046 - Access Study Personnel Elevator to Sump.

18. AMF Drawing No. HF-T-1049 - Access Top of Launcher Platform.

19. AMF Drawing No. HF-T-1062 - Access Envelope Launcher Platform Seal & Umbilical Junction Box.

20. AMF Drawing No. HF-T-1063 - Alternate Guide Roller Access Layout.

21. AMF Drawing No. HF-T-1065 - Upper Silo Access Layout.

22. AMF Drawing No. HF-T-1067 - Cat Walk Stairway to Bridge (OSTF & TF).

23. AMF Drawing No. HF-T-1068 - Platform Envelope at #8 Elevator Stop. .

24. AMF Drawing No. HF-T-1069 - Study - Access Area to Work Platform #5.

25. AMF Drawing No. HF-T-1090 - Stairway Study Elevation 380'-392'.

26. AMF Drawing No. HF-T-1122 - TF & OB Leak Check Envelope - Elevation 355'-9".

27. AMF Drawing No. HF-T-1119 TF-1 Leak Check Envelope - El. 307'-5¼".

# Chapter 26

## Human Factors Review and Evaluation of the Work Platforms

OBSTRUCTION

Railings stored at the elevator entrance prohibit free access to and from the elevator. Guard rails should be stored in the same quadrant in which they are used and out of passageways.

COLOR CODING

Underside of folding tabs have been caution striped to indicate that they are not in position.

ACCESS

All parts must be accessible for easy remove and replace.

FAIL SAFE

Work Platform over-center linkage design prevents collapse in the event of power failure.

FIGURE 26-1
HUMAN FACTORS INPUTS
WORK PLATFORMS

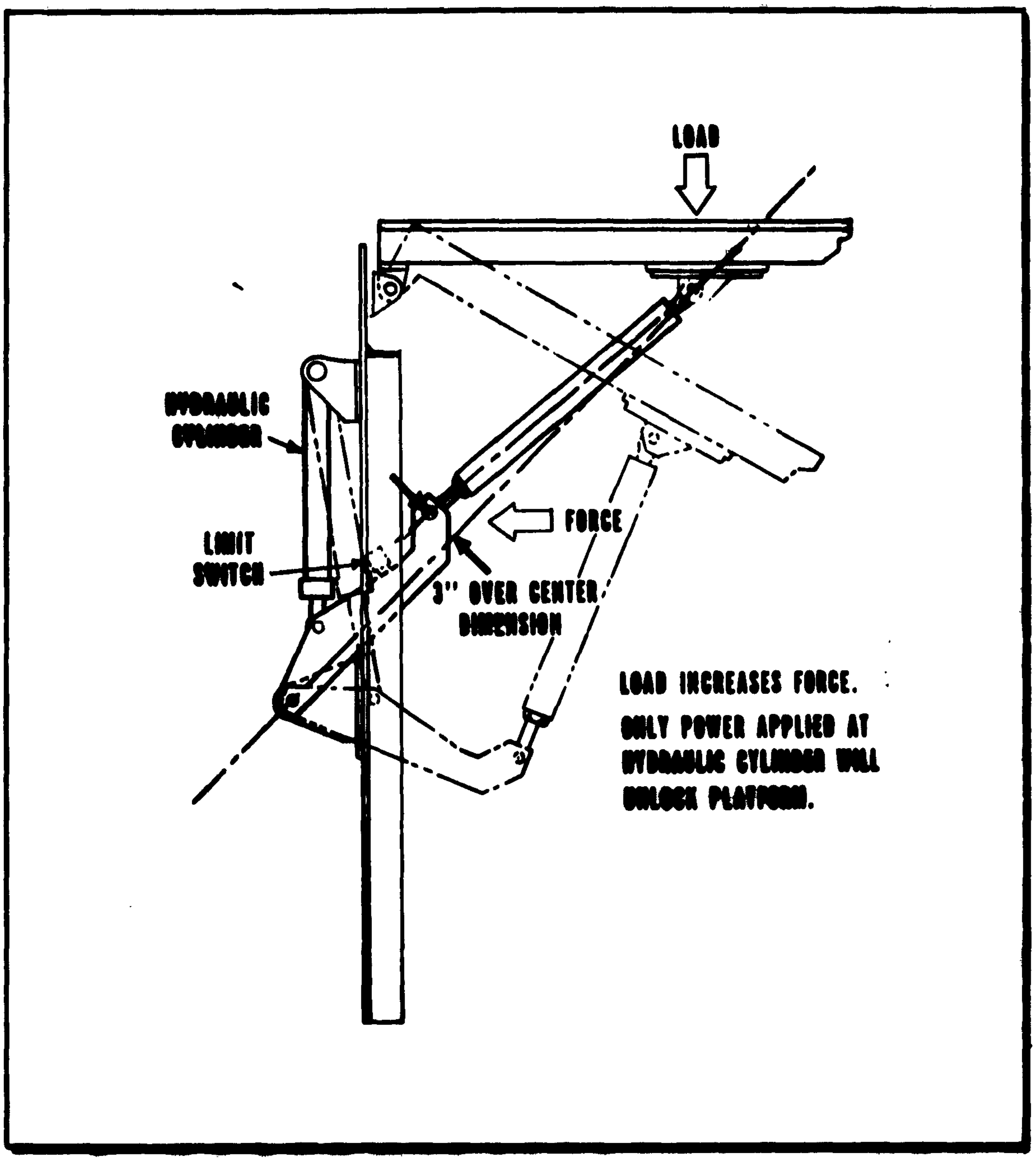
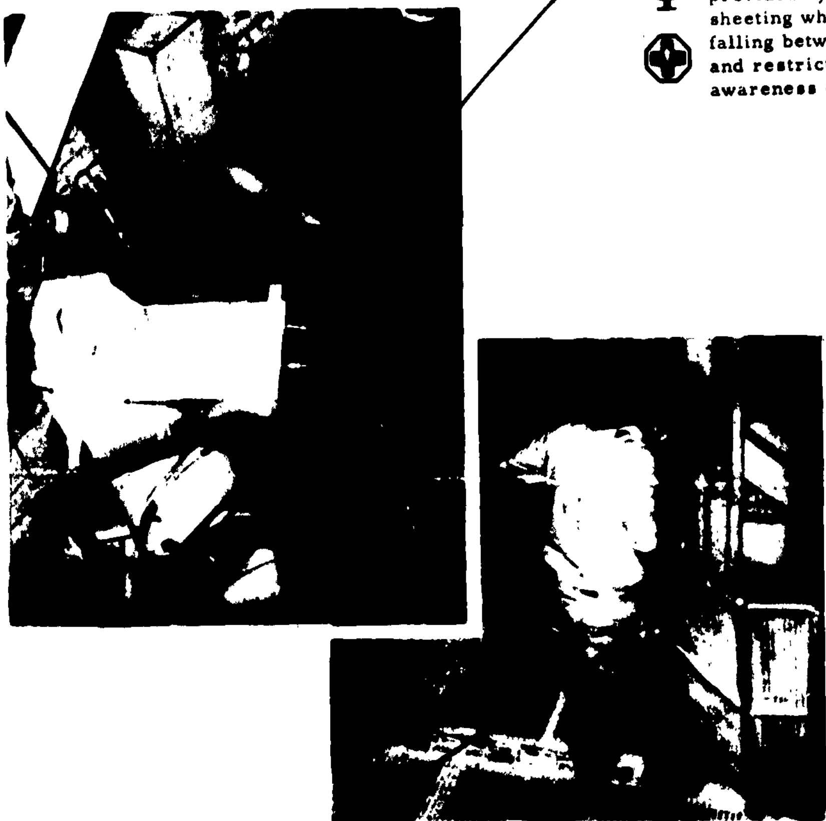



FIGURE 26-2
**FAIL SAFE WORK PLATFORM DESIGN**

FEELING OF SECURITY

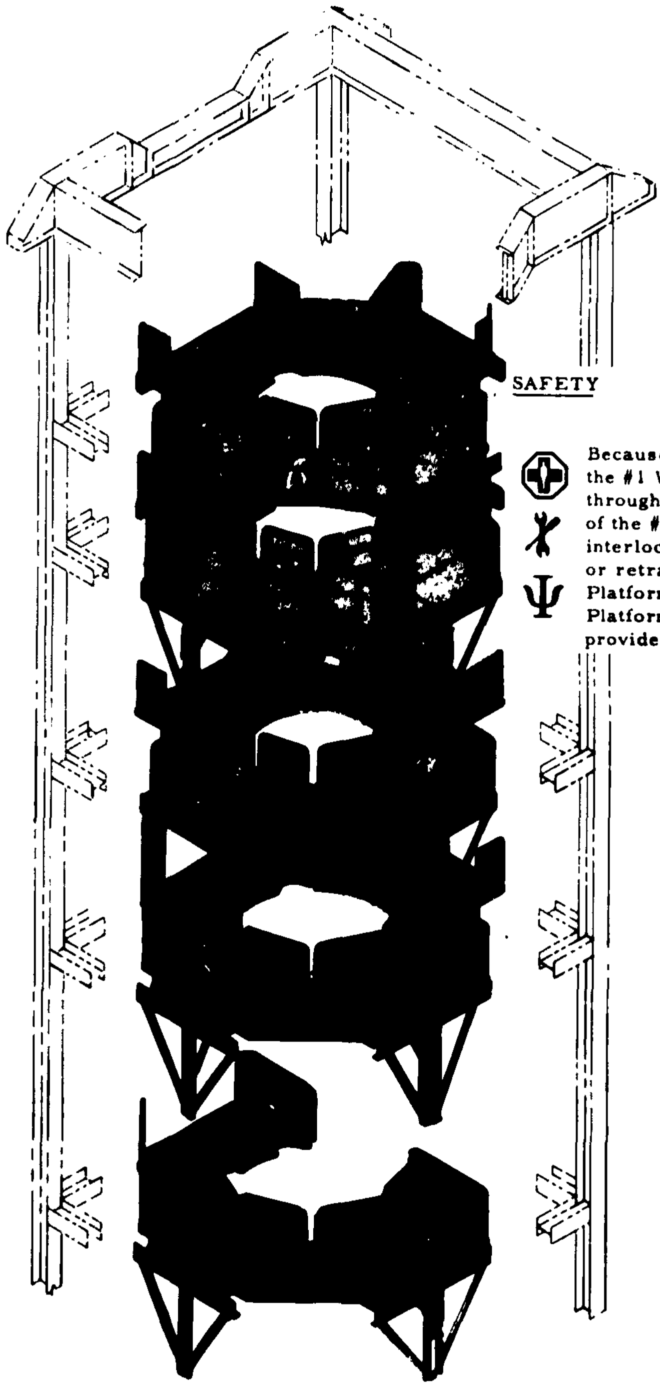
Feeling of security has been provided by expanded metal sheeting which prevents falling between the railings and restricts the visual awareness of height.



HANDLING

Handrail sections should be simplified for ease of emplacement.

FIGURE 26-3
WORK PLATFORM
GUARD RAILS



## SAFETY

Because a down folding leaf of the #1 Work Platform passes through the personnel envelope of the #2 Work Platform, an interlock preventing extension or retraction of the #1 Work Platform when the #2 Work Platform is extended has been provided.

FIGURE 26-4
RETRACTABLE
WORK PLATFORM
LEVELS

**SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO:**
WORK PLATFORMS

| | Item | Human Factor Effort Required | Phase in Stage: Concept | Phase in Stage: Review | Phase in Stage: Analysis | Phase in Stage: Field Input | Human Factors Objective: Specification Compliance | Human Factors Objective: Safety | Human Factors Objective: Operational Status | Human Factors Objective: Maintenance Recommendation | Human Factors Objective: Product Improvement | Applicable on Model: OSTF | Applicable on Model: TF | Applicable on Model: OB | Symbol |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | **HUMAN ENGINEERING DESIGN FACTORS** | | | | | | | | | | | | | |  |
| 1.1 | **Anthropometric Compatability** | * | * | * | | * | | | | | | * | * | * | |
| 1.2 | **Controls and Displays** | * | * | * | | * | | | | | | * | * | * | |
| 1.3 | **Fail-Safe Design** | * | * | * | * | | | | * | | * | * | * | * | |
| 1.4 | **Malfunction Detection** | * | * | * | * | | | | * | | * | * | * | * | |
| 2.0 | **MAINTENANCE FACTORS** | | | | | | | | | | | | | |  |
| 2.1 | **Access, Visual** | | | | | | | | | | | | | | |
| 2.2 | **Access, Servicing** | * | * | * | * | | * | * | | | | * | * | * | |
| 2.3 | **Remove and Replace** | * | * | * | * | * | | * | | | | * | * | * | |
| 2.4 | **Handling, Physical Limitations** | * | * | * | * | | * | * | | | | * | * | * | |
| 2.5 | **Handling, Transportation** | | | | | | | | | | | | | | |
| 2.6 | **Vehicle Maneuverability** | | | | | | | | | | | | | | |
| 3.0 | **SAFETY FACTORS** | | | | | | | | | | | | | |  |
| 3.1 | **Chemical Decontamination** | | | | | | | | | | | | | | |
| 3.2 | **Escape Provisions** | * | * | * | * | | * | * | | | | * | * | * | |
| 3.3 | **Protection from Entanglement** | | | | | | | | | | | | | | |
| 3.4 | **Protection from Falling** | * | * | * | * | | * | * | | | | * | * | * | |
| 3.5 | **Safety Devices (other)** | * | * | * | * | * | | * | | | | * | * | * | |
| 3.6 | **Warning Devices** | | | | | | | | | | | | | | |
| 4.0 | **PHYSIOLOGICAL FACTORS** | | | | | | | | | | | | | |  |
| 4.1 | **Biological Damage** | | | | | | | | | | | | | | |
| 4.2 | **Vertigo** | | | | | | | | | | | | | | |
| 4.3 | **Vibration Effects** | | | | | | | | | | | | | | |
| 5.0 | **PSYCHOLOGICAL FACTORS** | | | | | | | | | | | | | |  |
| 5.1 | **Fear of Heights** | * | * | * | * | | * | * | | | | * | * | * | |
| 5.2 | **Fear of Being Crushed** | | | | | | | | | | | | | | |
| 5.3 | **Fear of Falling** | * | * | * | * | | * | * | | | | * | * | * | |
| 5.4 | **Fear of Isolation** | | | | | | | | | | | | | | |
| 5.5 | **Feeling of Insecurity** | * | * | * | * | | * | * | | | | * | * | * | |
| 6.0 | **ENVIRONMENTAL FACTORS** | | | | | | | | | | | | | |  |
| 6.1 | **Acoustic Energy (noise)** | | | | | | | | | | | | | | |
| 6.2 | **Humidity & Temperature** | | | | | | | | | | | | | | |
| 6.3 | **Illumination** | * | * | * | * | | * | * | | | | * | * | * | |
| 7.0 | **HUMAN USE FACTORS** | | | | | | | | | | | | | |  |
| 7.1 | **Procedure** | * | | | * | | | | | | | * | * | * | |
| 7.2 | **Time Study** | | | | | | | | | | | | | | |
| 7.3 | **Training/Selection** | | | | | | | | | | | | | | |

FIGURE 26-5

## 1.0 DESCRIPTION

1.1 The basic concept for the design and location of Work Platform levels was established to provide missile access and maintenance to the umbilicals. An additional consideration was access to AMF and associate contractor's crib mounted utilities.

There are five work platforms located one each at the following elevations: 379'-6", 370'-6", 355'-9", 342'-3", and 323'-7".

Each platform level is divided into segments which fold hydraulically against the inner faces of the crib. Levels 1, 2, 3, and 4 are comprised of four segments while level 5 is restricted to three segments by the umbilical loop envelope. Manually folded and unfolded leaves bridge the gaps between each segment so that personnel and equipment can move around the circumference of the missile. Electrical interlocks provide assurance that every leaf is folded and locked to the main segment before retraction can be started, since an unfolded leaf would interfere mechanically with cable, guide rollers, etc., when the segment is fully retracted. Key switch stations provide protection to personnel working on a specific level. The removal of a key from either of two stations prevents actuation of the retraction mechanism controls for that level. Kickplates and removable guard rails 42" in height are provided to improve safety factors. There is a flexible trough (platform-to-missile seal) on all work platforms adjacent to the missile. This trough prevents tools from dropping off the platform.

1.2 Men of the Air Force population who represent body sizes between the 5th and 95th percentile must be able to control and use the work

platforms easily and safely. The extended platforms must provide adequate area to maneuver maintenance vehicles, and their related components should be designed for ease of maintenance.

Factors contributing to the successful use of the work platforms have been itemized on the summary checklist (Fig. 26-5) and the progress of the design program relating to the work platforms has been tabulated in detail in the following synopsis.

ITEM: WORK PLATFORMS

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: CONTRACTUAL AFBM 57-8A | DOCUMENTARY COMPLIANCE: TECH. REF. | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION: ANAL | VERIFICATION: EQUIP | VERIFICATION: TEST | RESULTS | % RELATIVE VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 HUMAN ENGINEERING DESIGN FACTORS<br>1.1 ANTHROPOMETRIC COMPATABILITY | 6.1.1 | ADS-2004A | PERSONNEL RANGING IN SIZE FROM THE 5TH TO THE 95TH PERCENTILE MUST BE ABLE TO USE THIS EQUIPMENT EFFICIENTLY AND SAFELY. | PERSONNEL MUST REACH 5'-0" FROM #1 W.P. TO SERVICE MISSILE PER WR-TPS-108. | RECOMMENDED INCREASE IN WIDTH OF PLATFORMS TO IMPROVE ACCESSIBILITY AND ELIMINATE SOME OF FOLDING TABS. | X | X | | NOT ADOPTED. | 5 |
| 1.2 CONTROLS AND DISPLAYS | 2.1.1.1, 2.3.1, 3.1.2.2.4, 3.1.3.1, 3.1.3.2, 3.1.3.4, & 3.2.1 | ADS-1003C 3.2.1, 3.2.5, 4.10, 4.11, 4.15, 5.0, & 6.41E ADS-2004A | FEED BACK TO SAFE GREEN LIGHTS MUST BE FROM WORK PLATFORM SEGMENT LIMIT SWITCHES TO BE EFFECTIVE INDICATION OF SAFE CONDITION. | REVIEWED D.D.L. & E.P.D. DOWN FOLDING SECTION OF #1 W.P. PASSES THRU PERSONNEL ENVELOPE OF #2 W.P. | RECOMMEND CHANGE IN CIRCUITRY TO PREVENT OPERATION OF #1 WORK PLATFORM WHEN #2 W.P. IS EXTENDED. | X | X | | #1 AND 2 INTERLOCKS (I.E. #1 DOES NOT OPERATE WHEN #2 IS EXTENDED). | 10 |
| | | | | A TEST WAS CONDUCTED TO EVALUATE WORK PLATFORM DESIGN AND CONTROLS WITH RESPECT TO ACCEPTABLE HUMAN FACTORS ENGINEERING PRINCIPLES. SEE ADTP-F-2055, ADDENDUM A. | TIMES TO PERFORM TESTS ARE TABULATED IN THE RESULT COLUMN. | | | X | 0:2:12 (2 MEN EMPLACEMENT)<br>0:2:45 (2 MEN RETRACTION)<br>0:5:06 (1 MAN EMPLACEMENT)<br>0:4:23 (1 MAN RETRACTION) | |
| 1.3 FAIL SAFE DESIGN | 1.4 AND 2.1.6 | ADS-2004A ADS-1003C | EFFORT SHOULD BE MADE TO ACHIEVE A FAIL SAFE DESIGN. | REVIEWED D.D.L. & E.P.D. ER-V-176 AND ER-V-142 REV. A AO-59-2410. | TWC WILL REVIEW THEIR EQUIPMENT TO IMPROVE USE OF SAME IN RELATION TO AMF EQUIPMENT. | X | X | | W. PLATFORM OVER-CENTER DESIGN PREVENTS COLLAPSE DUE TO POWER FAILURE.<br>TWC FOUND AMF HAD MORE THAN ADEQUATELY HANDLED THE WORK PLATFORMS AND RELATED AREAS. | 10 |
| 2.0 MAINTENANCE FACTORS<br>2.2 ACCESS, SERVICING | 4.3.2.3, 4.3.3.7.1, 4.3.3.8.2, & 4.3.3.9.4 | ADS-2004A | CONNECTION POINTS SHOULD BE ACCESSIBLE. | REVIEWED D.D.L. & E.P.D. | DESIGN CONNECTION POINTS TO BE ACCESSIBLE. | X | X | | CONNECTION POINTS ARE NOT ACCESSIBLE WITHOUT SUPPLEMENTAL EQUIPMENT. | 5 |

2.0 SYNOPSIS

ITEM: WORK PLATFORMS

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: CONTRACTUAL AFBM 57-8A | DOCUMENTARY COMPLIANCE: TECH. REF. | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION: ANAL | VERIFICATION: EQUIP | VERIFICATION: TEST | RESULTS | % RELATIVE VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.4 HANDLING, PHYSICAL LIMITATIONS | 4.3.3.1, 4.2.1, 4.3.3.6.8 & 4.3.3.9.1.4 | ADS-2004A | PROVISIONS SHOULD BE MADE FOR LIFTING WEIGHTS. (OVER 35 LBS.) | REVIEWED D.D.L. & E.P.D. ADTP-V-2055. | REDUCE GUARD RAIL WEIGHTS AND SIMPLIFY THE SECTIONS TO MAKE THEM EASIER TO INSTALL. | X | X | X | NOT ADOPTED. GUARD RAIL 1A2 & 1B8 ON MAIN PLATFORM WEIGHED 41 LBS. (SHOULD NOT EXCEED 35). | 5 |
| | | | SIDE LEAVES (TABS) SHOULD BE LIGHT WEIGHT. | REVIEWED D.D.L. & E.P.D. STAGE SEPARATION EQUIPMENT INTERFERES WITH 1A W.P. ACTUATING MECHANISM. REVIEWED E.P.D. | EXTENSION HANDLES FOR FOLDING TABS. GUARD RAILS SHOULD BE STORED IN THE SAME QUADRANT IN WHICH THEY ARE USED, SUGGEST EXTENSION RAILING ELIMINATING CURVED SECTIONS. | | | | NOT ADOPTED. | 10 |
| 3.0 SAFETY FACTORS 3.2 ESCAPE PROVISIONS | | ADS-2004A | PASSAGEWAYS FOR ESCAPE SHOULD NOT BE OBSTRUCTED. | REVIEWED EPD ER # 219. | GUARD RAILS WHEN STORED SHOULD NOT BLOCK ACCESS TO & FROM PERSONNEL ELEVATOR. STUDIES WERE MADE SHOWING POSSIBLE CHANGES IN GUARD RAIL STORAGE. | X | | | NOT ADOPTED. COST DID NOT MERIT THE SLIGHT IMPROVEMENT TO BE REALIZED. AUTOMATIC FOLD GUARD RAILS NOT ADOPTED. | 5 |
| 3.4 PROTECTION FROM FALLING | 7.5, 7.8, & 7.9 | ADS-2004A | PERSONNEL MUST BE PROTECTED FROM INJURY DUE TO FALLING. | REVIEWED D.D.L. & E.P.D. | ADAPT AUTOMATIC GUARD RAILS SUCH AS THOSE USED ON ABOVE GROUND SYSTEM. ALL WORK PLATFORM OPEN EDGES SHOULD HAVE GUARD RAILS. | X | | | UNPROTECTED AREAS FILLED BY UNISTRUT AND PIPE RAILINGS. | 10 |
| 3.5 SAFETY DEVICES (OTHER) | 7.19 & 7.22 | ADS-1003C ADS-2004A | COLOR CODE ALL HAZARDOUS AREAS. | REVIEWED D.D.L. & E.P.D. RECOMMENDED THAT W.P. #1 & #2 BE INTERLOCKED FOR SPECIAL SEQUENCE. RAILINGS LEFT OFF #1 W.P. (MISSILE GUIDE). | ADDITIONAL SAFETY DEVICES TO BE USED WHEN EXTENDING AND RETRACTING TABS AND GUARD RAILS. COLOR CODE UNDERSIDE OF FOLDING TABS. | X | X | | COLOR CODING OF WORK PLATFORMS APPROVED. | 10 |

2.0 SYNOPSIS

ITEM: WORK PLATFORMS

| HUMAN FACTORS | DOCUMENTARY COMPLIANCE: CONTRACTUAL AFBM 57-8A | DOCUMENTARY COMPLIANCE: TECH. REF. | CRITERIA FOR SUCCESS | APPLICATION OF CRITERIA: PARTICIPATION | APPLICATION OF CRITERIA: RECOMMENDATIONS | VERIFICATION: ANAL | VERIFICATION: EQUIP | VERIFICATION: TEST | RESULTS | % RELATIVE VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| 5.0 PSYCHOLOGICAL FACTORS<br>5.1 FEAR OF HEIGHTS | SEE 3.4 | ADS-2004A | RAILINGS MUST PROVIDE MAXIMUM PROTECTION FROM FALLING. | ER-TPS-82. | USE EXPANDED METAL OVER HAND RAIL OPENINGS. | X | X | | WORK PLATFORMS HAVE EXPANDED METAL BETWEEN RAIL OPENINGS. | 5 |
| 5.3 FEAR OF FALLING | SEE 3.4 | ADS-2004A | EFFICIENT USE OF PROCEDURES REQUIRED WHEN OPERATING. | | | | | | | 5 |
| 5.5 FEELING OF INSECURITY | | ADS-2004A | INSECURITY MUST BE MINIMIZED. | REVIEWED DDL & EPD | RECOMMENDED COVER ON GUARD RAILS TO OBSTRUCT VIEW BEYOND EDGE OF WORK PLATFORM. | X | X | | COVERS ADDED TO GUARD RAILS. | 5 |
| 6.0 ENVIRONMENTAL FACTORS<br>6.3 ILLUMINATION | 5.5, 5.5.1, 5.5.3, & 7.21 TABLE 3 | ADS-2004A | MOST WORK AREAS REQUIRE AT LEAST 25 FOOT CANDLES. | | | X | | | PRESENTLY BEING STUDIED BY TMC. | 15 |
| 7.0 HUMAN USE FACTORS<br>7.1 PROCEDURE | | | NO INTERFERENCES BETWEEN SECTIONS, ALL SECTIONS WHEN EXTENDED SHOULD HAVE SAME ELEVATION (IN RELATION TO WORK LEVEL). | ADTP-V-2055 (H.F. TEST PROCEDURE FOR EVALUATION OF THE WORK PLATFORMS.)<br>ARPP-V-2255 (H.F. TEST PROCEDURE FOR WORK PLATFORM & GUARD RAIL INST. TESTS). | | X | | X | TEST INCOMPLETE. | |
| 7.2 TIME STUDY | | | EFFICIENT USE OF TIME AS DETERMINED BY PROCEDURAL STUDY. | PROCEDURES PREPARED BUT NOT COMPLETED. | | X | | X | TEST INCOMPLETE. | |
| | | | | | | | | | | 100 |

## 3.0 DISCUSSION

The work platforms were originally developed to satisfy missile access requirements. They are also used during maintenance operations for access to various components mounted on the crib structure such as umbilical mechanisms and utility lines. The basic design has remained relatively unchanged since its early concept, although several changes have been recommended which would improve the equipment with respect to safety and efficiency. Examples of these recommendations are as follows:

a. Clearing access to the personnel elevator for easier passage to and from the work platforms,

b. Storage of the guard rails in the same quadrant where they are used for faster, safer, and more efficient assembly and disassembly,

c. Redesign of guard rails to straighten all curved sections for easier storage and to simplify manufacturing; extension handles for some of the platform folding tabs to reduce the hazard of falling; and redesign of some work platforms to improve accessibility, with the added possibility that some of the folding tabs would be eliminated to reduce the number of safety hazards.

During the design concept stage, Human Factors recommended automatic folding platform extension leaves and automatic guard rails which would insure optimum personnel protection and also decrease overall system maintenance time requirements. These recommendations were not incorporated into the Titan platform designs because austerity was considered to be

of prime importance. Experience in actual use with the existing work platforms will determine whether time and safety factors outweigh the initial cost of an automated system that may warrant retrofit at a later date.

## 4.0 REFERENCES


1. AFBM Exhibit 57-8A, Human Engineering Design Standards for Missile System equipment.

2. ADS-1003C, Personnel Safety for WS 107A-2 Launcher System.

3. ADTP-V-2055, Addendum A, Test Procedure for Exercising Launcher Work Platforms.

4. AHFP-V-2255, Human Factors Test Procedure for Work Platform and Guard Rail Installation Tests.

5. ADS-2004A, Design Specification Work Platforms for WS 107A-2 Launcher System.

6. AMF Report, MR-TPS-108, Personnel Must Reach 5'-0" from W. P. #1 to Service Missile.

7. AMF Report, ER-V-176, Work Platform Key Switches.

8. AMF Report, ER-V-142, Rev. A, Hazards in Operation of Work Platforms.

9. AMF Report, ER-TPS-219, Evaluation of Railing Storage for Work Platforms for WS 107A-2 Launcher System, TB & OB.

10. AMF Report, ER-TPS-202, Evaluation of Work Platforms for WS 107A-2 Launcher System for TB and OB.

11. AMF Report, ER-TPS-124, Crib Mounted Work Platform Locations.

12. AMF Drawing No. HF-T-1069, Study Access Area to Work Platform #5.

13. AMF Drawing No. HF-T-1101, Key Station for Work Platforms.

14. AMF Drawing No. HF-T-1112, Hazardous Marking Areas - Work Platforms 1 thru 6.